Catalogue Data in Autumn Semester 2022

Agricultural Sciences Bachelor

1. Semester

First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-2001-02L</td>
<td>Chemistry I</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel</td>
</tr>
</tbody>
</table>

Abstract

General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course “Chemistry I”, the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

Objective

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content

1. Stoichiometry
   Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
   Elementary particles and atoms. Electron configuration of the elements. Periodic system.
4. Basics of chemical thermodynamics
   System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
6. Second law of thermodynamics
   Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
   Law of mass action. Reaction quotient and equilibrium constant. Phase transition equilibrium.
9. Acids and bases
10. Dissolution and precipitation.
    Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes

Online-Skript mit durchgerechneten Beispielen.

Literature


Weiterführende Literatur:


Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical Knowledge</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<td></td>
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</tbody>
</table>

Social Competencies

| Communication                | not assessed                        |          |
| Cooperation and Teamwork    | not assessed                        |          |
| Customer Orientation        | not assessed                        |          |
| Leadership and Responsibility| not assessed                        |          |
| Self-presentation and Social Influence| not assessed|          |
| Sensitivity to Diversity    | not assessed                        |          |
| Negotiation                 | not assessed                        |          |

Personal Competencies

| Adaptability and Flexibility| not assessed                        |          |
| Creative Thinking           | assessed                            |          |
| Critical Thinking           | assessed                            |          |
| Integrity and Work Ethics  | not assessed                        |          |
| Self-awareness and Self-reflection| not assessed|          |
| Self-direction and Self-management| assessed|          |

401-0251-00L Mathematics I

O 6 credits 4V+2U A. Cannas da Silva

Abstract

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Data: 01.11.2022 12:41 Autumn Semester 2022
Objective
Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both these courses.

Content
1. Single-Variable Calculus:
- review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

2. Linear Algebra and Complex Numbers:
- systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

3. Ordinary Differential Equations:
- separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

Literature
- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

Prerequisites / notice
Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Level</th>
<th>Instructor(s)</th>
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<tbody>
<tr>
<td>701-0243-01L</td>
<td>Biology III: Essentials of Ecology</td>
<td>3V</td>
<td>2V</td>
<td>C. Buser Moser</td>
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<tr>
<td>701-0027-00L</td>
<td>Environmental Systems I</td>
<td>2 credits</td>
<td>2V</td>
<td>C. Schär, N. Dubois, G. Velicer</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2 of 2416
The lecture provides a science-based exploration of environmental aspects from three research fields: earth, climate, and health sciences.

The students are able to explain important properties of the three environmental systems, to discuss critical drivers, trends and conflicts of their use, and to compare potential solutions.

The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of raw materials and fossil fuels, climate change and its impacts on man and environment, and the spread and control of infectious diseases in the human population and agricultural systems.

Slides are provided by instructors and are accessible via moodle.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-0013-00L</td>
<td>World Food System</td>
<td>O</td>
<td>4 credits</td>
<td>4V</td>
<td>B. Studer, A. Bearth, R. Finger, I. Herer-Aeberli, M. Loessner, M. Niu, M. Peydayesh, J. Six</td>
</tr>
<tr>
<td>351-1158-00L</td>
<td>Economics</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>U. Renold, T. Boll, P. McDonald, M. E. Oswald-Egg, F. Pusterla, A. Zubovic</td>
</tr>
</tbody>
</table>

Knowledge about the World Food System will be provided, based on case studies along food value chains in countries with various development stages and dependent on multiple boundary conditions. This shall generate profound understanding of the association of subsequent specific courses within a general context. The course equivalently implements agricultural and food sciences, thus supporting the interdisciplinary view on the WFS scope.

Case studies on certain foods of plant and animal origin serve to demonstrate the entire food value chain from the production of raw material to processed food and its consumer relevant property functions. In doing so, important corresponding aspects for developed, emerging and developing countries are demonstrated, by use of engineering as well as natural and social science approaches.

Handouts and links are provided online.

Information on books and other literature references is communicated during the course.

The course shall particularly elucidate the cross section of Agro- and Food Sciences in the context of important global problems to be solved. Furthermore the students in the first year of studies shall be given some insight and outlook supporting the development of their views and interests in agricultural and food sciences further.

The course is part of the block exam after the first study year. Paper copies can be used ("Open Book") during the on-line exam, but no other means are allowed. The course is mainly taught in German, single might be in English.

This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

After successful completion of the course you will be able to:

- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

Not for students belonging to D-MTEC!


Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
- Critical Thinking
- Self-direction and Self-management

Method-specific Competencies

- Economic reasoning
- Microeconomics
- Macroeconomics

Personal Competencies

- Self-direction and Self-management
- Problem-solving
- Critical Thinking
- Decision-making

ÀÀÀ Additional First Year Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>751-0801-00L</td>
<td>Fundamentals of Microscopy and Plant Biology</td>
<td>O</td>
<td>1 credit</td>
<td>1V+2G</td>
<td>E. B. Truernit</td>
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Capability of preparing biological specimen, microscopy and documentation. Understanding the correlation between plant structure and function at the level of organs, tissues and cells.

Awareness of the link between plant anatomy, systematics, physiology, ecology, and development.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 3 of 2416

The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytic and synthetic tasks: Selected samples (e.g. soil and water) will be analysed with various methods, such as titrations, spectroscopy or ion chromatography. The chemistry of aqueous solutions (acid-base equilibria and solvatation or precipitation processes) is studied. The synthesis of simple inorganic complexes or organic molecules is practised. Furthermore, the preparation and handling of environmentally relevant gaseous species like carbon dioxide or nitrogen oxides is a central subject of the Praktikum.

The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g. investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

The handling of chemicals and proper laboratory techniques represent the main learning targets. Furthermore, the description and recording of laboratory processes is an essential part of this course.

The experiments cover a wide range of analytic and synthetic tasks:

- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

The students learn to

- analyse and interpret data from experiments,
- present results in a structured manner,
- reflect on the relevance of their results.

This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

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- process and analyze real-world data from their subject of study.

- choose and apply appropriate tools from computer science.
Literature

Friedhelm Kuipers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Wiley-VCH, 2012
ISBN 3527411445, 9783527411443

Douglas C. Giancoli
Physik
3. erweiterte Auflage
Pearson Studium

Hans J. Paus
Physik in Experimenten und Beispielen
Carl Hanser Verlag, München, 2002. 1068 S.

Paul A. Tipler
Physik
Spektrum Akademischer Verlag, 1998, 1522 S., ca Fr. 120.-

David Halliday, Robert Resnick, Jearl Walker
Physik
Wiley-VCH, 2003, 1388 S., Fr. 87.- (bis 31.12.03)

dazu gratis Online Ressourcen (z.B. Simulationen): www.halliday.de

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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</tr>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
<td>not assessed</td>
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<tr>
<td>Decision-making</td>
<td>not assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
</tbody>
</table>

Social Competencies

Communication

not assessed

Mathematics III: Systems Analysis

4 credits

2V+1U

C. Brunner, R. Knutti, S. Schemm, H. Wernli

Abstract

The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective

Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content

https://iac.ethz.ch/edu/courses/bachelor/vorbereitung/systemanalyse.html

Lecture notes

Overhead slides will be made available through the course website.


Mathematics IV: Statistics

4 credits

2V+1U

J. Ernest

Abstract

Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

Objective

Capacity to learn from data: good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.

Content


Lecture notes

Ausführliches Skript zur Vorlesung ist erhältlich.

Literature


Prerequisites / notice

Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

Voraussetzungen: Mathematik I, II

Microbiology

2 credits

2V

M. Ackermann, M. Schuppler, J. Vorholt-Zambelli

Abstract

Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

Objective

Teaching of basic knowledge in microbiology.

Content


Lecture notes

Wird von den jeweiligen Dozenten ausgegeben.

Literature

Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

Pedosphere

3 credits

2V

R. Kretzschmar

Abstract

Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.
Objective
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

Content
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

Lecture notes
Polybook

Prerequisites / notice
Prerequisites: Basic knowledge in chemistry, biology and geology.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

751-1311-00L Introduction to Agricultural Management O 2 credits 2V R. Finger
Abstract Vermittlung von betriebswirtschaftlichen Grundlagenwissen und Analyse- und Planungsinstrumenten mit Anwendung auf Unternehmen der Agrar- und Ernährungswirtschaft
Objective Teilnehmer des Kurses sollen am Ende der Vorlesung i) grundlegende Unternehmensentscheide strukturieren und analysieren können, ii) verschiedene Analyse- und Planungsinstrumente auf Fragestellungen der Produktionsplanung, Investition und Finanzierung an Beispielen anwenden zu können, iii) verschiedene Werkzeuge zur unternehmerischen Entscheidungsunterstützung anwenden können und iv) die Spezifika von Unternehmen in der Agrar- und Ernährungswirtschaft kennen.

Content
Die Vorlesung geht auf folgende Inhalte, mit spezifischen Anwendungen im Agrar- und Ernährungssektors ein:
Grundlagen und Ziele unternehmerischen Entscheidens
Kosten und Leistungsrechnung
Produktionstheorie
Produktionsprogrammplanung
Investitionsplanung und Finanzierung
Entscheidungen unter Unsicherheit und Risikomanagement

Lecture notes
Vorlesungsunterlagen werden im Laufe des Semesters zur Verfügung gestellt

Literature

752-6003-00L Introduction to Nutritional Science O 2 credits 1.5V M. B. Zimmermann, C. Wolfrum

Abstract
This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fats and carbohydrates.

Objective
To introduce the students to the both the macro- and the micronutrients.

Content
The lectures on micronutrients are given by Prof. Zimmermann and the lectures on macronutrients are given by Prof. Wolfrum. Prof. Zimmermann discusses the micronutrients, including fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. Prof. Wolfrum introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism.

Lecture notes
There is no script. Powerpoint presentations will be made available.

Literature
Elmadfa I & Leitzmann C: Ernährung des Menschen UTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004
Garrow JS and James WPT: Human Nutrition and Dietetics Churchill Livingstone, Edinburgh, 11th rev. ed. 2005

Agricultural Sciences Basic Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>751-8003-00L</td>
<td>Genetics in Agricultural Sciences</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>H. Pausch, B. Studer</td>
</tr>
</tbody>
</table>

Abstract
Important concepts from population, quantitative and molecular genetics are introduced and applied to plant and animal populations.

Objective
After the course, the students will be able to
- work with genetic polymorphisms and explain mechanisms underlying allele frequency changes in natural and experimental populations;
- determine factors affecting the selection intensity
- explain the difference between genotypic and phenotypic values
- quantify the expected genetic gain per time unit
- explain important molecular methods to determine genetic polymorphisms;
- map traits in plant and animal populations using molecular marker information;
- integrate different concepts from population, molecular and quantitative genetics and explain their importance for applications in genetics in agricultural sciences.
Molecular genetics (15%)
- DNA sequence variation
- Marker & genotyping technologies (SSRs, AFLPs, SNPs, KASP, GBS, RADseq, AmpSeq, Chip Technologies)

Population genetics (30%)
- Allele- and genotype frequencies in populations
- Hardy-Weinberg equilibrium
- Genetic drift, differentiation of populations
- Fitness, selection
- Inbreeding, relationship, effective population size

Quantitative genetics (40%)
- Recombination, crossing over, linkage analysis, genetic mapping
- QTL mapping
- Forms of selection and selection differential
- Heritability
- Quantification of expected genetic gain
- genotypic value, allele substitution effect, breeding value

Integrative genetics (15%)
- Genome-wide association mapping
- Estimation of genomic breeding values

Lecture notes
Slides and exercises will be provided in advance of each class via Moodle

Literature
Further reading:
Falconer & Mackay: Introduction to Quantitative Genetics
Lübberstedt & Varshney: Diagnostics in Plant Breeding

► Agricultural Sciences Disciplines

►► Agricultural Economics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>351-1109-00L</td>
<td>Introduction to Microeconomics</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>M. Wörter, M. Beck</td>
</tr>
</tbody>
</table>

GESS (Science in Perspective):
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real-world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
<td>not assessed</td>
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<tr>
<td>Project Management</td>
<td>not assessed</td>
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</tbody>
</table>

| Method-specific Competencies                  |          |          |
| Cooperation and Teamwork                     | not assessed |
| Customer Orientation                          | not assessed |
| Leadership and Responsibility                 | not assessed |
| Self-presentation and Social Influence        | not assessed |
| Sensitivity to Diversity                      | not assessed |
| Negotiation                                   | not assessed |

| Social Competencies                           |          |          |
| Communication                                 | not assessed |
| Adaptability and Flexibility                  | not assessed |
| Creative Thinking                             | not assessed |
| Critical Thinking                             | assessed |
| Integrity and Work Ethics                     | not assessed |
| Self-awareness and Self-reflection            | not assessed |
| Self-direction and Self-management            | not assessed |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 7 of 2416
Content

- Der Agrar- und Lebensmittelsektor in der EU und der Schweiz
- Preiselastizitäten von Angebot und Nachfrage im Ernährungssektor
- Gewinnmaximierung
- Grundlagen der Spieltheorie
- Monopol / Monopolistischer Wettbewerb
- Oligopol (Stackelberg, Cournot, Bertrand)
- Monopson
- Produktdivergenzierung
- Preisdiskriminierung

Lecture notes

Handed out during lecture

Literature


Prerequisites / notice

Empfohlene Vorkenntnisse:
- Grundkenntnisse der Ökonomie/Agrarökonomie
- Vorlesung Einführung in die Mikroökonomie

Fostered competencies

Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Decision-making
Social Competencies: Negotiation
Personal Competencies: Critical Thinking

Objective

Students will be able to a) solve linear and non-linear optimization problems in the context of agricultural production; b) properly interpret the results; and c) critically discuss the economic implications.

Content

The course is an application of Operations Research (OR). First, the theory and application of linear programming (LP) is presented. Students will learn the underlying principles (Optimization, Duality, Simplex) and solve exercises in the context of agricultural production. In the second part of the course, the foundation of non-linear programming (NLP) is introduced (Lagrange, Kuhn-Tucker) and illustrated with various examples.

Lecture notes

Handed out during lecture

Literature


Fostered competencies

Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Analytical Competencies

Objective

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different resource-concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for an in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Literature

751-3700-00L Plant Ecophysiology  O  2 credits  2V  N. Buchmann, A. Walter

Abstract
The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO2 concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO2 gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data is included.

Objective
The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Content

Lecture notes
Handouts stehen online.

Literature

Prerequisites / notice
This course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems.

Fostered competencies

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<tr>
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751-3401-00L Plant Nutrition I  O  2 credits  2V  E. Frossard

Abstract
The aim of these lecture is to present the processes controlling the uptake and transport of nutrients by the plant, the assimilation of nutrients in the plant, the effect of nutrients on crop yield and quality, the role of the soil as a source of nutrients for crops, and the basic principles of fertilization of different crop types using mineral and organic fertilizers.

Objective
At the end of the lecture, students know how mineral nutrients are taken up through roots and circulate in the plants and what their roles in plants are. They understand the importance of nutrients for yield formation and for crop product quality. They are able to propose fertilization plans adapted for field crops growing under Swiss conditions.

Content
A general introduction explains the needs of appropriately managing nutrients in plant production. Afterwards, we will study the physiology of plant nutrition (nutrient uptake by roots; nutrient transports in the plant; physiological roles of nutrients in the plant). Then the role of nutrients for yield formation and their effects on crop quality is dealt with. Finally, the bases of crop fertilization are taught (availability of nutrient in soil; N, P and K fertilization; different types of fertilizers).

Lecture notes
The slides will be distributed

Literature
Schubert S 2006 Pflanzennährung Grundwissen Bachelor Ulmer UTB
http://www.tll.de/visuplant/vp_idx.htm

751-4108-00L Innovation in Smart Farming  W+  3 credits  2G  A. Walter

Number of participants limited to 16.

A motivation letter must be submitted after the first lecture Monday 26 September (maximum 100 words) until Wednesday 28 September to Achim Walter (Achim.Walter@usys.ethz.ch). A confirmation of the definitive registration for the course will be communicated on Friday 30 September. The definitive registration for the course will be undertaken by the study secretariat.

Abstract
Agriculture needs to become more sustainable via innovative approaches. This course allows students to explore in group work, how this could be realized. There are short impulse talks on ‘Smart Farming’ given by experts on technology and entrepreneurship. Most importantly, students elaborate the first steps to create a startup company in this field.

Objective
During the course, the students generate their own ideas on ‘Smart Farming’. They explore, which technologies provide possibilities for a more sustainable agriculture. They realize trade-offs between economic and technological possibilities.

Content
The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.)

1. Systematically analyse and discuss case studies from ongoing agroecological and food system research.

This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gull, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytopathogenic and mycopathogenic. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisaatin and pistasin demethylase. Local and systemic acquired resistance (LAR, SAR). Induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes

Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

751-5003-00L  Sustainable Agroecosystems II  W+  2 credits  2V  K. Benabderrazik, J. Six

Abstract  This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Objective  (1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.

(2) Learn and experiment on methods for field and laboratory investigations in agroecology.

(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.

(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.

(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content  The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) in both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management).

The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors’ roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholders in the food system in order to support a sustainable transformation.


Prerequisites / notice  Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.
The importance and specificities of the different horticultural crops are shown in this course in the autumn semester. It deals with fruit growing (8 h), berry production (4 h), vegetables (6 h) and viticulture (6 h).

You are able to describe the production systems of the horticultural crops fruits, berries, vegetables and viticulture (yield formation and physiology, cultivation methods, main varieties, quality factors).

You are able to assess the importance of new conditions (climate, politics, trade) for the production of horticultural crops and identify options for action for production.

The importance and specificities of the different horticultural crops are shown in this course in the autumn semester. It deals with fruit growing (8 h), berry production (4 h), vegetable growing (6 h) and viticulture (6 h).

Under the responsibility of Agroscope representatives, basic knowledge of production systems (yield formation and physiology, cultivation methods, main varieties, quality) of these horticultural crops, which are important in Switzerland, is imparted.

Delivered during the lectures by the different teachers, Moodle upload.

The lecturers will recommend additional literature at the beginning of the course.

This lecture is part of the BSc programme in Agricultural Sciences (3rd semester)

The overall goal of this course is to enable students to understand basic functions of the vertebrate organism and to comprehend pathophysiological correlations.

Handouts are provided by each lecturer separately.

The lectures will recommend additional literature at the beginning of the course.

This course is part of the BSc programme in Agricultural Sciences (3rd semester)
Zusammen mit nervaler Kontrolle, spielen Hormone und Zytokine als Signalmediatoren eine besondere Rolle bei der Regulation der

The basics of planning of feeding and formulation of diets incl. the implications on nutrient cycles and balances are taught. In the part dealing with ruminants, forage-based diets and the application of feed formulation programs are central and exercised on-farm. With pigs and poultry, the basics of energy and nutrient requirements are deepened through practical examples.

Students are able to attend the exam on the only possible date of the 3.11.2022 from 14-16h is a prerequisite.

The knowledge of the nutrition of ruminants and of the feeds used is deepened. Particular emphasis is put on the variety of home-grown feeds, their production and conservation and their application in the nutrition of dairy cows, cattle and small ruminants. Finally, information on specific problems of animal nutrition is communicated.

Blockkurs in Halbtagesform; eingeschlossen sind Betriebsbesuche. Fach mit benoteter Semesterleistung.

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purchase of basic skills in agricultural livestock nutrition.
This lecture with exercises gives an introduction to the scientific work with data, starting with data acquisition and ending with statistical analyses. Students will get an introduction to the scientific work with data covering all steps from data import from Excel via statistical analyses to producing correct scientific graphical output. Exercises with the software R/RStudio will provide hands-on opportunities to get acquainted with data analysis and presentation in adequate graphs. Field data gathered with Prof. E. Frossard will be used.

### Methods

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-0441-00L</td>
<td>Scientific Analysis and Presentation of Data</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>H. Pausch, N. K. Kadri, A. Leonard</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Students will get an introduction to the scientific work with data covering all steps from data import from Excel via statistical analyses to producing correct scientific graphical output. Exercises with the software R/RStudio will provide hands-on opportunities to get acquainted with data analysis and presentation in adequate graphs. Field data gathered with Prof. E. Frossard will be used.</td>
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<tr>
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<td>Objective</td>
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<td>This lecture with exercises gives an introduction to the scientific work with data, starting with data acquisition and ending with statistical analyses as they are often required for a bachelor thesis (descriptive statistics, linear regression, simple analyses of variance etc.). Using open-source R/RStudio software will be the primary focus via a hands-on approach. An important aspect will be to learn which graphical representation of data are best suited for the task (how can data be presented clearly and still scientifically correct?)</td>
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<tr>
<td></td>
<td>Content</td>
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<td>Tentative Programme:</td>
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<td>- Preparation of own data from field course with Prof. E. Frossard / from 4th semester</td>
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<td>- Correct and problematic graphical data displays</td>
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<td>- Statistical distribution and confidence intervals</td>
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<td>- Statistical tests - Repetition and hands-on applications</td>
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<td>- Correlation analysis</td>
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<td>- Linear regressions</td>
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<td>- Analysis of Variance</td>
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<td>- Discussion of ANOVA results with Prof. E. Frossard</td>
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<td>Last week of semester: examination (Leistungskontrolle)</td>
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<td></td>
<td>Lecture notes</td>
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<td>Mainly German (with some English passages from text books)</td>
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<td>Prerequisites / notice</td>
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<td>Theoretical background in ensemble statistics from the mandatory course in the 4th semester; students should have cleared the examination of that fundamental course to be able to follow</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Die Studierenden kennen die Grundlagen und die Konventionen des wissenschaftlichen Schreibens in den Naturwissenschaften, können wissenschaftliche Literatur suchen und verwalten sowie wissenschaftliche Publikationen analysieren. Sie setzen das Gelernte beim Schreiben eines eigenen Textes um.</td>
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<td>Prerequisites / notice</td>
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<td>Die Note für LV Wissenschaftliches Arbeiten (Teil I: Grundlagen (WiA) und Teil II: Wissenschaftliches Schreiben (WiSch)) setzt sich aus den Leistungen der Lehrveranstaltungen im 4. und S. Semester zusammen. Die Note für WiSch (5. Sem.) zählt zu 80% zur Gesamtnote.</td>
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### Electives

The electives listed are recommended. However, electives can be chosen from the complete course offer of the ETH Zurich and University of Zurich.

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<thead>
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<tr>
<td>751-0903-00L</td>
<td>Microeconomics of the Agriculture and Food Sector</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>S. Wimmer</td>
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</table>

**Abstract**

In this Vorlesung werden ökonomische Charakteristika des Agrar- und Lebensmittelsektors herausgearbeitet und anderen Sektoren gegenübergestellt. Fokus ist dabei Lebensmittelindustrie in der Schweiz und in der EU. Es werden mikroökonomische Zusammenhänge, insbesondere zur Preis- und Mengenbildung in verschiedenen Wettbewerbsmodellen, im Fallbeispiel des Agrar- und Ernährungssektors vermittelt.

**Objective**


**Content**

- Der Agrar- und Lebensmittelsektor in der EU und der Schweiz
- Preiselastizitäten von Angebot und Nachfrage im Ernährungssektor
- Gewinnmaximierung
- Grundlagen der Spieltheorie
- Monopol / Monopolistischer Wettbewerb
- Oligopol (Stackelberg, Cournot, Bertrand)
- Monopson
- Produktionsdifferenzierung
- Preisdiskriminierung
- Kartelle

**Literature**


**Prerequisites / notice**

Empfohlene Vorkenntnisse:
- Grundkenntnisse der Ökonomie/Agrarökonomie

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Negotiation</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-0401-00L</td>
<td>Optimization of Agricultural Production Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. Huber</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction in to optimization of agricultural production systems with linear and non-linear programming models.

**Objective**

Students will be able to a) solve linear and non-linear optimization problems in the context of agricultural production; b) properly interpret the results; and c) critically discuss the economic implications.

**Content**

The course is an application of Operations Research (OR). First, the theory and application of linear programming (LP) is presented. Students will learn the underlying principles (Optimization, Duality, Simplex) and solve exercises in the context of agricultural production. In the second part of the course, the foundation of non-linear programming (NLP) is introduced (Lagrange, Kuhn-Tucker) and illustrated with various examples.

**Literature**


**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0537-00L</td>
<td>Resource and Environmental Economics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>L. Bretschger</td>
</tr>
</tbody>
</table>
Abstract

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare
during the course, the students generate their own ideas on 'Smart Farming'. They explore, which technologies provide possibilities for a

Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare

Literature


752-2120-00L Consumer Behaviour I

Abstract

Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individuual
determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Objective

Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individuual
determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

751-4108-00L Innovation in Smart Farming

Abstract

A motivation letter must be submitted after the first lecture
Monday 26 September (maximum 100 words) until
Wednesday 28 September to Achim Walter
(Achim.Walter@usys.ethz.ch). A confirmation of the
definitive participation in the course will be communicated
on Friday 30 September. The definitive registration for the
course will be undertaken by the study secretariat.

Objective

Agriculture needs to become more sustainable via innovative approaches. This course allows students to explore in group work, how this
could be realized. There are short impulse talks on 'Smart Farming' given by experts on technology and entrepreneurship. Most
importantly, students elaborate the first steps to create a startup company in this field.

Content

Further information can be found on: https://www.usys.ethz.ch/en/news-

751-4504-00L Plant Pathology I

Abstract

Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in
agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors
driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.

Objective

Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the
development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of pathogen-specific nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes
Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

751-5003-00L Sustainable Agroecosystems II W 2 credits 2V K. Benabderrazik, J. Six

Abstract
This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation

Objective
(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content
The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Literature

Prerequisites / notice
Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.
### Fostered competencies
- **Subject-specific Competencies**
  - Concepts and Theories assessed
- **Method-specific Competencies**
  - Analytical Competencies assessed
  - Problem-solving assessed
- **Social Competencies**
  - Cooperation and Teamwork assessed
  - Sensitivity to Diversity assessed
- **Personal Competencies**
  - Critical Thinking assessed
  - Self-awareness and Self-reflection assessed
  - Self-direction and Self-management assessed

### 751-7101-00L Applied Animal Nutrition
- **Abstract**
The basics of planning of feeding and formulation of diets incl. the implications on nutrient cycles and balances are taught. In the part dealing with ruminants, forage-based diets and the application of feed formulation programs are central and exercised on-farm. With pigs and poultry, the basics of energy and nutrient requirements are deepened through practical examples.

- **Objective**
The students are able, based on the knowledge they obtain in this course, to deal with problems in the nutrition of ruminants, pigs and poultry on farm.

- **Content**
  - Programmteil Wiederkäuer: Einführung in die Winterfütterungsplanung für Milchkühe, Betriebsbesuch (Erfassung aller notwendigen Daten inkl. Futterprobenentnahme für eine konkrete Planung auf einem Praxisbetrieb), Besonderheiten der Milchviehfütterung (Laktationsverlauf, Jahreszeit, etc.); Einführung in den LBL-Fütterungsplan, Möglichkeiten der Futterbeurteilung und -bewertung mit praktischer Beurteilung der gesammelten Proben, Berechnungen und Besprechung Fütterungsplan, Aufstellung der Mineralstoffbilanz, Vorführung von PC-Software zur Fütterungsplanung Vorstellen und diskutieren des Fütterungsplanes auf dem Praxisbetrieb durch die Gruppe.
  - Programmteil Nicht-Wiederkäuer: Der Energie- und spezifische Nährstoffbedarf beim Schwein und Geflügel; Besonderheiten der Fütterung in den verschiedenen Produktionsphasen; Fütterungsempfehlungen und hinweise. Rationengestaltung und Rezeptoptimierung für Mischfuttermittel anhand verschiedener Beispiele; Einsatzgrenzen von Futtermittel; technologische Futterbearbeitung.

### 751-7103-00L Animal Feed and Feeding of Ruminants
- **Abstract**
The knowledge of the nutrition of ruminants and of the feeds used is deepened. Particular emphasis is put on the variety of home-grown feeds, their production and conservation and their application in the nutrition of dairy cows, cattle and small ruminants. Finally, information on specific problems of animal nutrition is communicated.

- **Objective**
Purchase of basic skills in agricultural livestock nutrition.

- **Content**

### 751-6121-00L Regulatory Physiology
- **Abstract**
Zusammen mit nervaler Kontrolle, spielen Hormone und Zytokine als Signalmediatoren eine besondere Rolle bei der Regulation der Homöostase von Körperfunktionen (Flüssigkeits-, Temperatur-, Energie-Homöostase). Insbesondere im Zusammenhang mit pathologischen Konstellationen (Fieber, Stress, metabolische Imbalance, Schmerzen) wird diese komplexe Funktion verständlich.

- **Objective**

- **Content**
  - Thermoregulation (Fieber)
  - Flüssigkeits- und Energie-Homöostase
  - Calciumregulation
  - Energiehomöostase (Ketose)
  - Schmerz (zootechnische Eingriffe)
  - Stress (allostatische Last, Epigenetik)

### 751-6122-00L Autumn Semester 2022
- **Prerequisites / notice**
Blockkurs in Halbtagesform; eingeschlossen sind Betriebsbesuche. Fach mit benoteter Semesterleistung.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 17 of 2416
Agroecology (HS)  

In Spring Semester a related course (Agroecology FS) will be offered. The course Agroecology (HS) is not a prerequisite, the courses can be taken independent of each other.

Abstract  
Agroecology is a discipline, an agricultural practice, and a political-social movement. Students will attend five public lectures in which experts from different fields reflect on agroecology and its principles. Based on these inputs, students will reflect and discuss about the role of agroecology to support sustainable agriculture and food systems.

Objective  
Students know the thirteen principles of the High-Level Panel of Experts (HLPE) of the Committee on World Food Security as well as the ten elements of agroecology suggested by FAO and can critically reflect on the important properties as well as benefits and trade-offs of agroecological systems and approaches. Students will be able to transfer their disciplinary and interdisciplinary knowledge about the thirteen principles as guiding principles for policymakers, practitioners, and other stakeholders across the food system in planning, managing, and evaluating agroecological transformation. Students are part of groups focusing on one of 13 principles of the HLPE. During the course, students discuss the potential and limitations of agroecology and learn about scientific contributions to agroecology. Students form an opinion on the role of agroecology as well as to reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

Content  
The course is designed as a combination of a series of five public lectures/webinars on “Agroecology and the Transformation to Sustainable Food Systems” delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended to fuel the students’ sessions in the second part of each course. In the student sessions the student groups first get to know one of the 13 principles of the HLPE. During the course, students discuss the potential and limitations of agroecology and learn about scientific contributions to agroecology. Students form an opinion on the role of agroecology as well as to reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

Lecture notes  
Handouts will be available on the webpage of the course.

Literature  
Report of HLPE on agroecology:  
Prerequisites / notice  
This course is based on fundamental knowledge about plant ecophysiology, soil science, biogeochemistry, crop and forage science, and ecology in general. The course will be taught in English. The course is offered in spring and fall (different agroecology principles will be addressed). Thus, both courses are not sequential, but can be taken in any order.

Bachelor's Thesis  

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tr>
<td>751-1020-10L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>14 credits</td>
<td>30D</td>
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Agricultural Sciences Bachelor - Key for Type  

<table>
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<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-  Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z  Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr  Suitable for doctorate</td>
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<tr>
<td>Key for Hours</td>
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<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
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<td>K</td>
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<td>P</td>
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<td>A</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS
- European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Educational Science

<table>
<thead>
<tr>
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<th>Title</th>
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<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
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<td>2</td>
<td>2V</td>
<td>E. Stern</td>
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<td></td>
<td>This course looks into scientific theories and also empirical studies on human learning and relates them to the school.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td></td>
<td>This course is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
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<tr>
<th>851-0242-06L</th>
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<th>2 credits</th>
<th>2S</th>
<th>R. Schumacher</th>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td>- Get information about recent literature on learning and instruction</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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</tbody>
</table>

| 851-0242-07L | Human Intelligence                                      | W          | 1    | 1S                | E. Stern                   |
|--------------|---------------------------------------------------------|------------|------|-------------------|
|              | **Abstract**                                            |            |      |                   |
|              | The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed. |            |      |                   |
|              | **Objective**                                            |            |      |                   |
|              | - Understanding of research methods used in the empirical human sciences |            |      |                   |
|              | - Getting to know intelligence tests                     |            |      |                   |
|              | - Understanding findings relevant for education           |            |      |                   |

<table>
<thead>
<tr>
<th>851-0242-08L</th>
<th>Research Methods in Educational Science</th>
<th>W</th>
<th>1</th>
<th>2S</th>
<th>C. M. Thurn, T. Braas,</th>
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<tbody>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.</td>
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<td></td>
<td>- Understand research methods used in the empirical educational sciences</td>
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<td>- Understand and critically examine information from scientific journals and media</td>
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<td>- Understand pedagogically relevant findings from the empirical educational sciences</td>
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<table>
<thead>
<tr>
<th>851-0240-22L</th>
<th>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</th>
<th>2 credits</th>
<th>3S</th>
<th>U. Markwalder, S. Maurer, S. Peteranderl-Rüschoff</th>
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</thead>
<tbody>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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</table>
Gender Issues In Education and STEM ■

**Abstract**

In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM); Common perspectives, controversies and empirical evidence will be discussed.

**Objective**

- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives
- To integrate this knowledge with teacher's work.

**Content**

Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

**Prerequisites / notice**

Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

**ECTS** 2 credits

**Number of participants limited to 30.**

<table>
<thead>
<tr>
<th>851-0228-00L</th>
<th>Formation of Knowledge in STEM Fields in Primary and Secondary School ■</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to high-performing Children, language problems etc.)</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.</td>
</tr>
</tbody>
</table>

**Note:** Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-9020-00L</td>
<td>Teaching Internship Including Examination Lessons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural Science ■</td>
<td>The teaching internship can just be visited if all other courses of TC are completed. Repetition of the internship is excluded even if the examination lessons are to be repeated.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.</td>
<td></td>
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<tr>
<td><strong>Content</strong></td>
<td>- They role in the teaching trade. They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.</td>
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<tr>
<td></td>
<td>- They learn to assess pupils’ work.</td>
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<tr>
<td></td>
<td>- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.</td>
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</tr>
</tbody>
</table>

**Structure:**

- **Subject Didactics and Professional Training**

**Number of participants limited to 30.**

<table>
<thead>
<tr>
<th>751-9020-00L</th>
<th>Teaching Internship Including Examination Lessons Agricultural Science ■</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The teaching internship can just be visited if all other courses of TC are completed.</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.</td>
</tr>
</tbody>
</table>

**Note:** Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.
### Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

### Objective

- The aim is for the students
  - to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
  - to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
  - To try out different options for specialist further training in their profession.

### Content

#### Thematische Schwerpunkte:


#### Lernformen:


### Lecture notes

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

### Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

### Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

---

### Agricultural Sciences TC - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E- Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr Suitable for doctorate</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P practical/laboratory course</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
</tr>
</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Agricultural Sciences Master
▶ Major in Animal Sciences
► Disciplinary Competences
►► LivestockSystems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-6501-00L</td>
<td>Ruminant Science</td>
<td>W+</td>
<td>4</td>
<td>4G</td>
<td>M. Niu, M. Terranova, U. Witschi</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course provides the scientific basis of the central aspects of reproduction and nutrition physiology of ruminants, and of the implications for animal health, product quality, and breeding programs. Means of knowledge transfer include interdisciplinary approaches, disciplinary parts, web-based learning and self-study.</td>
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<tr>
<td>Objective</td>
<td>At the end of the course the students are able to apply, by a comprehensive understanding of the underlying mechanisms, their knowledge in various fields of ruminant science. They will be able to develop and recommend best strategies for breeding programs, feed formulation, improving forage quality, and increasing animal health. They will be trained to carry out interdisciplinary and disciplinary research at the highest level.</td>
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<tr>
<td>Content</td>
<td>Fields (contact hours)</td>
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<td></td>
<td>- Introduction: 2 h</td>
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<td>- Special topics: 20 h</td>
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<td></td>
<td>- Rumen Anatomy</td>
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<td></td>
<td>- Hohenheim Gas Test</td>
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<td></td>
<td>- Calf health</td>
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<td></td>
<td>- Reproduction Techniques</td>
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<td>- Fertility in Cows</td>
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<td></td>
<td>- Disciplinary topics: 32 h</td>
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<td>- Ruminal Digestion: 8 h</td>
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<td></td>
<td>- Ruminant Nutrition Physiology: 12 h</td>
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<td></td>
<td>- Reproduction in Ruminants: 8 h</td>
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<td></td>
<td>- Lectures held by the students: 4 h</td>
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<tr>
<td>In summary</td>
<td>- Contact hours: 58 h</td>
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<td></td>
<td>- Self-study within semester: 30 h (especially preparation for the interdisciplinary courses and the own lecture)</td>
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<td></td>
<td>- Self-study in semester break: 32 h</td>
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<td></td>
<td>Total: 120 h</td>
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<tr>
<td>Lecture notes</td>
<td>Documentations, links and other materials will be provided at the start of the course</td>
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<tr>
<td>Literature</td>
<td>Information on books and other references will be communicated during the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Conditions for successful participation: Background on animal science from the Bachelor is desired. In order to attend the Minor in Ruminant Science without any animal science background, a realistic self-assessment concerning the need for additional self-study is recommended (e.g. by choosing an appropriate bachelor course which then may be counted as 'optional courses' in the master). These efforts depend on the extent to which animal science courses have already been attended in the bachelor.</td>
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<td></td>
<td>The control of performance will consist of:</td>
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<td>- an own short lecture</td>
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<td></td>
<td>- a final oral examination with focus on comprehension of the fundamental linkages rather than of specific details</td>
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<tr>
<td>751-6001-00L</td>
<td>Forum: Livestock in the World Food System</td>
<td>W+</td>
<td>2</td>
<td>1S</td>
<td>S. Meese</td>
</tr>
<tr>
<td>Abstract</td>
<td>This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.</td>
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<tr>
<td>Objective</td>
<td>In the Forum &quot;Livestock in the World Food System&quot;, a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.</td>
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<tr>
<td>Content</td>
<td>The Forum &quot;Livestock in the World Food System&quot; will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:</td>
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<tr>
<td></td>
<td>Part 1</td>
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<td></td>
<td>Aspect 1 - Oral presentation: The students form small groups and are lecturers.</td>
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<td></td>
<td>Aspect 2 - chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.</td>
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<tr>
<td></td>
<td>Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.</td>
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<tr>
<td>Lecture notes</td>
<td>Introductions to both presentation forms will be given by the lecturer.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Requirements for allocation of the two credit points:</td>
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<tr>
<td></td>
<td>- oral talk with sufficient handout</td>
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<tr>
<td></td>
<td>- delivery of the scientific writing in sufficient quality</td>
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<tr>
<td></td>
<td>- active participation during all presentations (in case of absence there will be additional tasks)</td>
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</tr>
<tr>
<td>Feedback on the presentation style of a student</td>
<td></td>
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</tr>
<tr>
<td>751-2105-00L</td>
<td>Political Ecology of Food and Agriculture</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>J. Jacobi</td>
</tr>
<tr>
<td>Number of participants limited to 25</td>
<td>A motivational application is required:</td>
<td></td>
<td></td>
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</tbody>
</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 23 of 2416
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Questions regarding the application to johanna.jacobi@usys.ethz.ch.

Abstract
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective
- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools.

For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production.

Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Literature
Literature list provided on Moodle.

Moodle: https://moodle-app2.let.ethz.ch/mod/assign/view.php?id=756049

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity to Diversity</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Negotiation</td>
<td>Self-awareness and Self-reflection</td>
</tr>
</tbody>
</table>


Livestock Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-7211-00L</td>
<td>Ruminal Digestion</td>
<td>W+</td>
<td>1 credit</td>
<td>1G</td>
<td>not available</td>
</tr>
</tbody>
</table>

Does not take place this semester.

Abstract
This course broadens the knowledge in one of the most important aspects of ruminant nutrition: the microbial digestion in the rumen (and in the hindgut). For a comprehensive understanding of the rumen microbial ecosystem, the mechanisms of nutrient fermentation and the synthesis of microbial protein, thorough basics are provided. Apart from lectures, group and laboratory exercises are included.

Objective
The course enables students to understand in detail how ruminal digestion works and how this knowledge can be applied to design optimal feeding diets using highly fibrous forages and a variety of other feeds. The students also are able to show how to modify the most important rumen microbes beneficially by nutritional means.

Content
Structure of the contact hour part of the course (16 h):

2 h Introduction and blackboard exercise

8 h Basic topics in ruminal digestion, lectures and group exercises:
- Systematics of the microbes involved in microbial digestion
- Measurement of microbial digestion
- Interactions of microbes and epithelium of the digestive tract
- Differences between ruminal and hindgut microbial digestion
- Microbial nutrient degradation and its modification
- Efficiency of microbial protein synthesis
- Manipulation of the ruminal digestion

4 h exercise at AgroVet-Strickhof:
- Measurements of microbial digestion
- Laboratory exercise with a rumen fistulated cow and a Rumen Simulation Technique

2 h Final seminar

The non-contact hour part is to comprehend the information given and to prepare either the written report or the oral presentation (cf. “Besonderes”).

Lecture notes
Lecture notes are provided via Moodle.

Literature
Will be communicated at the start of the course.

Prerequisites / notice
The course is a balanced mixture of blackboard exercise, laboratory exercise, group exercise, lecture and student seminar presentation.

Credit point associated with grade of either a written report or an oral presentation in the final seminar (both on a self-chosen related topic)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-6113-00L</td>
<td>Endocrinology and Biology of Reproduction</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>S. E. Ulbrich, S. M. Bernal Ulloa</td>
</tr>
</tbody>
</table>

Endokrinologie und Reproduktionsbiologie der Säugetiere und des Menschen (Anatomie, Morphologie, Physiologie, Regelmechanismen)

Die Systematik der Reproduktionshormone und der Hormonrezeptoren wird erläutert, die Wirkungsmechanismen (Bildung; orale Bioverfügbarkeit; Elimination) erklärt. Mit diesen Grundlagen wird das Verständnis der Regulation der Fortpflanzung umfassend erörtert.

Data: 01.11.2022 12:41   Autumn Semester 2022
The teaching slides and other materials will be provided during the course.

At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

The course gives an overview into different classes of bioactive components present in food and feed including fatty acids and secondary plant compounds such as carotenoids, polyphenols, phytosterogens, glucosinolates, protease inhibitors and monoterpenes.

Topics include:
- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

Lecture notes
The teaching slides and other materials will be provided during the course.

Literature
Information about books and other references will be communicated during the course.

Seminar in Evolutionary Ecology of Infectious Diseases

This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific basic principles of genetic evaluations

Objective
At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

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Topics include:
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- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

Lecture notes
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Literature
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Topics include:
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- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

Lecture notes
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Literature
Information about books and other references will be communicated during the course.

Seminar in Evolutionary Ecology of Infectious Diseases

This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific basic principles of genetic evaluations

Objective
At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

The course gives an overview into different classes of bioactive components present in food and feed including fatty acids and secondary plant compounds such as carotenoids, polyphenols, phytosterogens, glucosinolates, protease inhibitors and monoterpenes.

Topics include:
- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

Lecture notes
The teaching slides and other materials will be provided during the course.

Literature
Information about books and other references will be communicated during the course.

Seminar in Evolutionary Ecology of Infectious Diseases

This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific basic principles of genetic evaluations

Objective
At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

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Topics include:
- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

Lecture notes
The teaching slides and other materials will be provided during the course.

Literature
Information about books and other references will be communicated during the course.
Abstract

Different experimental designs will be discussed and various statistical tools will be applied to research questions in agroecosystem sciences. Statistical methods range from simple analysis of variance to mixed-models and multivariate statistics. Surveys and manipulative field and laboratory experiments are addressed and students learn to analyse data using a hands-on approach.

Objective

Students will know various statistical analyses and their application to science problems in their study area as well as a wide range of experimental design options used in environmental and agricultural sciences. They will practice to use statistical software packages (R), understand pros and cons of various designs and statistics, and be able to statistically evaluate their own results as well as those of published studies.

Content

The course program uses a learning-by-doing approach ("hands-on minds-on"). The topics are introduced as short lectures, but most of the work is done on the computer using different packages of R – a software for statistical computing and graphics. In addition to contact hours exercises must be finalized and handed in for grading. The credit points will be given based on successful assessments of selected exercises.

The tentative schedule contains the following topics:

- Data handling and data exploration with tidyverse
- Designs of field and growth chamber experiments theory
- Design creation with DiGGen
- Fitting linear mixed-effects models with lme4
- Marginal means estimation and post-hoc tests with emmeans
- Nonlinear regression fits
- Statistical learning techniques
- Principle component analysis, canonical correpondence analysis (CCA), cluster analysis
- Random forest

This course does not provide the mathematical background that students are expected to bring along when signing up to this course. Alternatively, students can consider some aspects of this course as a first exposure to solutions in experimental design and applied statistics and then deepen their understanding in follow-up statistical courses.

Lecture notes

Handouts will be available (in English)

Literature

A selection of suggested additional literature, especially for German speaking students will be presented in the introductory lecture.

Prerequisites / notice

This course is based on the course Mathematik IV: Statistik, passed in the 2nd year and the Bachelor's course "Wissenschaftliche Datenauswertung und Datenpräsentation" (751-0441-00L)

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Method-specific Competencies
- assessed

751-6127-00L Practical Course in Microscopy of Functional Histology

W+ 3 credits 6P

Does not take place this semester.

Abstract

Die "Funktionelle Histologie" beschreibt die histologischen und zytologischen Strukturen mit ihren jeweiligen Aufgaben und Wechselwirkungen innerhalb ausgewählter Organsysteme. Die endokrinologisch relevanten Organe und deren Präparation werden am Beispiel des Rindes kennengelernt.

Objective

Grundlagen der Histologie; Gewebedünnschnitte (Gefrier- und Paraffinschnitte) und deren Übersichtsfärbungen und Immunhistochemie; Fortgeschrittene Mikroskopie von Gewebedünnschnitten; Kritische Bewertung von Physiologie/Pathologie aufgrund morphologisch/histologischer Kriterien

Content

Jeder/m Studierenden wird ein Organ zugeteilt, mit welchem sie/er sich intensiv theoretisch und praktisch auseinandersetzt. Anhand dieses Organes als rotem Faden, welches vom Schlachthof bereitgestellt und von den Studierenden selber seziert, eingebettet, geschnitten, gefärbt und mikroskopiert wird, werden die Lernziele erreicht.


Prerequisites / notice

In Form eines Vortrags werden den anderen TeilnehmerInnen das zugeteilte Organ bzw Gewebe bezüglich der Morphologie, Histologie und funktioneller Gesichtspunkte vorgestellt.

751-6129-00L Practical Course Epigenetics

W+ 3 credits 6P

Does not take place this semester.

Abstract

The practical course will comprise of lecture elements introducing the topic of epigenetics and a large amount of practical work where you will be able to perform DNA methylation analyses on your own. In particular, we will focus on DNA extraction and the estimation of global and local DNA methylation.

Objective

The competencies and aims for the course are:
- Get first hands-on experience with the experimental techniques.
- Answer a scientific question by conducting experiments.
- Obtain results of an experiment and get insight into what affects technical variation and thus influences reproducibility.
- Interpret results in an adequate manner to solve a scientific question.
- Combine results to draw an adequate conclusion.
- Present a research paper on epigenetics.

Lecture notes

You will receive in advance a selection of research papers, a document with the theoretical background of the techniques included in the course, the slides of the lessons in pdf and a detailed protocol of the work we will do.
For receiving a total of 3 Credit Points for this practical course we kindly ask you to actively take part in the practical performance. In addition, you will have to present an original research publication, address questions from your colleagues and actively participate in the discussion. The last day, you will need to pass a short written examination about the theoretical background of the techniques and results interpretation. Finally, after the course, you will have to write a lab report to be handed in at the beginning of the spring semester.

## Training Course in Research Groups (Large)

**W+ 6 credits 13P**

**Abstract**

The students will learn the conceptual and methodological background of research in the animal science groups of the Institute of Plant, Animal, and Agroecosystem Science. In addition to teaching the theoretical background, the major aim of the course is to integrate the students into the research groups (on job training) and, hence, to focus on the practical application of the knowledge.

**Objective**

- Introduction into the conceptual and methodological basis of research
- Integration of the students into the research groups (on job training)
- Application of the gained knowledge

**Content**

The students will be integrated into the research groups day-to-day work and will thus deal with all aspects of scientific work. This comprises the planning (conceptually and logically), execution (data collection, laboratory analyses) and evaluation (statistics, data presentation) of experiments as well as the basics of scientific writing (aim: later publication, Master thesis). The research topics and the range of methodologies vary between the animal science research groups in the Institute of Plant, Animal and Agroecosystem Sciences.

**Lecture notes**

None

**Literature**

Specific readings after enlisting in a particular research group.

**Prerequisites / notice**

The number of training slots in the various groups is limited. It is therefore highly recommended to contact the group leaders early enough (first come first serve). The full integration in a research group often means to work on weekends. The total time budget is equivalent to about 180 hours. Active participation in group meetings (discussion, presentation) and short written reports about the work conducted are required for the 6 credit points. There are no grades, it is only pass or fail.

## Training Course in Research Groups (Small)

**W+ 3 credits 6P**

**Abstract**

The students will learn the conceptual and methodological background of research in the animal science groups of the Institute of Plant, Animal, and Agroecosystem Science. In addition to teaching the theoretical background, the major aim of the course is to integrate the students into the research groups (on job training) and, hence, to focus on the practical application of the knowledge.

**Objective**

- Introduction into the conceptual and methodological basis of research
- Integration of the students into the research groups (on job training)
- Application of the gained knowledge

**Content**

The students will be integrated into the research groups day-to-day work and will thus deal with all aspects of scientific work. This comprises the planning (conceptually and logically), execution (data collection, laboratory analyses) and evaluation (statistics, data presentation) of experiments as well as the basics of scientific writing (aim: later publication, Master thesis). The research topics and the range of methodologies vary between the animal science research groups in the Institute of Plant, Animal and Agroecosystem Sciences.

**Lecture notes**

None

**Literature**

Specific readings after enlisting in a particular research group.

**Prerequisites / notice**

The number of training slots in the various groups is limited. It is therefore highly recommended to contact the group leaders early enough (first come first serve). The full integration in a research group often means to work on weekends. The total time budget is equivalent to about 90 hours. Active participation in group meetings (discussion, presentation) and short written reports about the work conducted are required for the 3 credit points. There are no grades, it is only pass or fail.

## Project Management for Scientific Research

### Number

**751-6001-00L**

**Title**

Forum: Livestock in the World Food System

**Type**

W+ 2 credits 1S

**ECTS**

S. Meese

**Lecturers**

Number of participants limited to 20.

**Abstract**

This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.

**Objective**

In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.

**Content**

The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

**Part 1**

1. **Aspect 1 - Oral presentation:** The students form small groups and are lecturers.
2. **Aspect 2 - chair person:** There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
3. **Aspect 3 - feedback:** At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

**Part 2**

1. **Aspect 1 - Scientific writing:** Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
2. **Aspect 2 - Defense:** There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Lecture notes

no scriptum
The educational objectives cover thematic, methodic as well as social and personal competencies:

**Concepts and Theories**
- Understanding of theories and principles in plant breeding
- Knowledge of the history and development of plant breeding
- Understanding of genetic concepts and their application in breeding

**Communication**
- Effective oral and written communication skills in the context of plant breeding
- Ability to present findings and ideas clearly and persuasively

**B. Studer, A. Hund, R. Kölliker**

During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops. Few crops dominate the crop rotations worldwide. Following the goal of increased agricultural biodiversity, species such as buckwheat and triticale might be valuable additions because they bring biodiversity and resilience to the production systems. Currently, the cultivation of many medicinal herbs is limited to certain areas, but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

On the second module, students gain practical knowledge on field - An integral part of the course is the two-week field project in a Tropical region, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

### Prerequisites / notice
We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 23rd 2022, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

### Content
This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, climate mitigation, agroecology, resilience to soil physics or agricultural economics. Students will engage in readings, discussions and exchanges on the specificities of tropical agriculture.

### Prerequisites / notice
- Oral discussion
- Delivery of the scientific writing in sufficient quality
- Active participation during all presentations (in case of absence there will be additional tasks)
- Feedback on the presentation style of a student

### Objective
- Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
- Interdisciplinary analysis of agricultural production systems
- Knowledge on methods to assess agroecological performance of a tropical agroecosystems
- Hands-on training on the use of field methods, diagnostic tools and survey methods.
- Gain practical knowledge on how to assess to climate resilience and farming systems.
- Collaboration in international students and stakeholders

### Fostered competencies

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Major in Plant Sciences

### Disciplinary Competences

### Agronomy and Plant Breeding

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-4104-00L</td>
<td>Alternative Crops</td>
<td>W+</td>
<td>2</td>
<td>2V</td>
<td>A. Walter, K. Berger Bütter</td>
</tr>
<tr>
<td>Abstract</td>
<td>Few crops dominate the crop rotations worldwide. Following the goal of increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.</td>
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<tr>
<td>Objective</td>
<td>During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.</td>
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</table>

| 751-3603-00L | Current Challenges in Plant Breeding Number of participants limited to 15. | W+   | 2    | 2G    | B. Studer, A. Hund, R. Kölliker |
| Abstract     | The seminar 'Current challenges in plant breeding' aims to bring together national and international experts in plant breeding to discuss current activities, latest achievements and future prospective of a selected topic/area in plant breeding. |
| Objective    | The educational objectives cover thematic, methodic as well as social and personal competencies: Thematic/methodic competencies: - Deepening of scientific knowledge in plant breeding - Critical evaluation of current challenges and new concepts in plant breeding - Promotion of collaboration and Master thesis projects with practical plant breeders Social/personal competencies: - Independent literature research to get familiar with the selected topic - Critical evaluation and consolidation of the acquired knowledge in an interdisciplinary team - Establishment of a scientific presentation in an interdisciplinary team - Presentation and discussion of the teamwork outcome - Establishing contacts and strengthening the network to national and international plant breeders and scientist |
Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).

**Lecture notes**
None

**Literature**
Peer-reviewed research articles, selected according to the topic.

**Prerequisites / notice**
Participation in the BSc course ‘Pflanzenzüchtung’ is strongly recommended, a completed course in ‘Molecular Plant Breeding’ is advantageous.

### Crop Health

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W+</td>
<td>2</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
</tr>
<tr>
<td>Abstract</td>
<td>This is an introductory class on insect ecology. The course will involve learning about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes lectures, small group discussions and outside readings.</td>
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<tr>
<td>Objective</td>
<td>The aim of the course is to gain an understanding of how insects have specialised and adapted to occupy diverse environmental niches and become vital to ecosystem processes. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions and examining insect ecology in an evolutionary context.</td>
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<tr>
<td>Content</td>
<td>Alien organisms in agriculture is a topic that receives increasing awareness among farmers, agricultural scientists, regulators and the general public. Students of this course will learn about the nature of alien organisms such as invasive species, biocontrol organisms and genetically modified organisms. With a particular focus on arthropods, plants and their interactions we will look at the potential threats the novel organisms pose, the benefits they provide and how both of these effects can be scientifically assessed. Students will learn how the topic of alien organisms in agriculture is intrinsically tied to policy making and regulation and get to know current examples and future challenges in research. In the last part of the course students will be able to apply the acquired knowledge in a practical exercise (case study).</td>
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<tr>
<td>Lecture notes</td>
<td>Provided to students through Moodle</td>
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<tr>
<td>Literature</td>
<td>Selected required readings (peer reviewed literature). Optional recommended readings with additional information.</td>
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### Problems

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.</td>
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<tr>
<td>Objective</td>
<td>This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.</td>
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<tr>
<td>Content</td>
<td>A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.</td>
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<tr>
<td>Lecture notes</td>
<td>Public and class notes can be downloaded from a web page announced during the lecture.</td>
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<tr>
<td>Literature</td>
<td>Papers will be assigned and downloaded from a web page announced during the lecture.</td>
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</table>

### Agriculture and Environment

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-5000-00L</td>
<td>Plant Pathology III</td>
<td>W+</td>
<td>2</td>
<td>2G</td>
<td>M. Maurohofer Bringolf</td>
</tr>
<tr>
<td>Abstract</td>
<td>Identification based on host, symptoms and micro-morphology, completed with life cycles and related control measures of the most important fungal diseases and their causal pathogens of annual and perennial crops with agricultural significance.</td>
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<tr>
<td>Objective</td>
<td>The students will learn and train preparation skills for microscopy, acquire knowledge of selected diseases (identification, biology of pathogen, epidemiology and systematics) and understand the corresponding integrated control measures practiced in Swiss agriculture.</td>
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<tr>
<td>Content</td>
<td>One exercise will be on an e-learning base (with computers) also to prepare the students for the final e-exam.</td>
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<tr>
<td>Lecture notes</td>
<td>A script will be used on annual and perennial crops and their most important diseases. It will be updated stepwise</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course will be in German (spec. nomenclature)</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>not assessed</td>
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</table>

**Data: 01.11.2022 12:41**

**Autumn Semester 2022**

**Page 29 of 2416**
This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems.

Objective
Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems, be able to analyze large meteorological and flux data sets, and evaluate the impacts of weather events and management practices, based on real-life data. Moreover, students will be able to coordinate and work successfully in small (interdisciplinary) teams.

Content
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems. Responses of agroecosystems to the environment, i.e., to climate and weather events, but also to management will be studied. Different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets and carbon sequestration. Thus, students will learn about the complex interactions of a coupled human-environmental system.

Students will work with real-life data from the long-term measurement network Swiss FluxNet. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

Lecture notes
Handouts will be available in moodle.

Prerequisites
Not assessed

Literature
Documents will be distributed during the lecture.
The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is the analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

### Seminar in Plant Sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-5115-00L</td>
<td>Current Aspects of Nutrient Cycle in Agro-Ecosystems</td>
<td>W+</td>
<td>2 credits</td>
<td>1S</td>
<td>E. Frossard, A. Oberson Dräger</td>
</tr>
</tbody>
</table>
| **Abstract** | The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is “Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments”.

**Objective** | Analyze publications and/or data records on long-term field experiments regarding their content on integrated nutrient management and derive the nutrient use efficiency; link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to answer overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.

**Content** | The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is “Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments”. The students will analyze and connect the results published (or from data records) for selected field experiments in a group work. They will present their analysis in a report and in an oral presentation. The seminar is composed by presentations of experts and of the students. The presentations will be synthesized during a final discussion.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
<td>Project Management</td>
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**Social Competencies**

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**Personal Competencies**

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<table>
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<tr>
<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<table>
<thead>
<tr>
<th>751-4003-01L</th>
<th>Current Topics in Grassland Sciences (HS)</th>
<th>W+</th>
<th>2 credits</th>
<th>2S</th>
<th>N. Buchmann</th>
</tr>
</thead>
</table>
| **Abstract** | Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

**Objective** | Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.

**Content** | Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

**Lecture notes** | none

**Prerequisites / notice** | Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.
The course program uses a learning-by-doing approach ("hands-on minds-on"). The topics are introduced as short lectures, but most of the work is done on the computer using different packages of R – a software for statistical computing and graphics. In addition to contact hours, there are computer exercises. The tentative schedule contains the following topics:

- Introduction to experimental design and applied statistics in R
- Data handling and data exploration with tidyverse
- Designs of field and growth chamber experiments theory
- Design creation with DiGGer
- Fitting linear mixed-effects models with lme4
- Marginal means estimation and post-hoc tests with emmeans
- Nonlinear regression fits
- Statistical learning techniques
- Principle component analysis, canonical correspondence analysis (CCA), cluster analysis
- Random forest

This course does not provide the mathematical background that students are expected to bring along when signing up to this course. Alternatively, students can consider some aspects of this course as a first exposure to solutions in experimental design and applied statistics and then deepen their understanding in follow-up statistical courses.

Lecture notes
Handouts will be available (in English)

Literature
A selection of suggested additional literature, especially for German speaking students will be presented in the introductory lecture.

Questions regarding the application to johanna.jacobi@usys.ethz.ch.

Answers
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Literature list provided on Moodle.
This course is based on the course Mathematik IV: Statistik, passed in the 2nd year and the Bachelor's course “Wissenschaftliche Datenauswertung und Datenpräsentation” (751-0441-00L).

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Conceptual and Theoretical understanding</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
<td></td>
<td>assessed</td>
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<table>
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<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>assessed</td>
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</table>

**Prerequisites / notice**

Students who enroll for this course are strongly recommended to verify with lecturers from other courses whether their absence of two weeks may affect their performance in the respective courses.

**Abstract**

This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in Ethiopia, which is co-organized with Eldoret University (Kenya) and KU Leuven (Belgium).

**Objective**

1. Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
2. Interdisciplinary analysis of agricultural production systems
3. Knowledge on methods to assess agroecological performance of a tropical agroecosystems
4. Hands-on training on the use of field methods, diagnostic tools and survey methods.
5. Gain practical knowledge on how to assess to climate resilience and farming systems.
6. Collaboration in international students and stakeholders

**Content**

This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, climate mitigation, agroecology, resilience to soil physics or agricultural economics. Students will engage in readings, discussions and exchanges on the specificities of tropical agriculture.

On, students gain practical knowledge on field - An integral part of the course is the two-week field project in a Tropical region, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

On the second module, students gain practical knowledge on field - An integral part of the course is the two-week field project in Kenya, conducting various assessments related to Food and Energy Security.

**Prerequisites / notice**

We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 23rd 2022, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

**Fostered competencies**

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<th>Subject-specific Competencies</th>
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<tr>
<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Decision-making</td>
<td>not assessed</td>
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<tr>
<td>Problem-solving</td>
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<td>Project Management</td>
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**Social Competencies**

<table>
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<tr>
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<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<tr>
<td>Negotiation</td>
<td>not assessed</td>
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**Personal Competencies**

<table>
<thead>
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<tr>
<td>Critical Thinking</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

**Number**

363-0403-00L

**Title**

Introduction to Marketing

**Type**

W+ 3 credits 2G

**Lecturers**

S. Brüggemann

**Abstract**

Students who take this course will increase their knowledge of marketing, its effect on consumer behavior and its role in creating long-term value. The course will introduce important concepts, frameworks and methods for marketing decision-making. A focus will be on managing customer relationships with the help of targeted promotions and data collected through digital technologies.

**Objective**

After taking the class, students will be able to

1. Define what marketing is and describe its role at different stages of the value chain
2. Apply psychological theories to analyze behavior (e.g., purchase behavior) and identify the needs of (prospective) customers in consumer and business markets
3. Design elements of the marketing mix—e.g., develop new products and set prices—in a way that creates long-term value
4. Create an effective and efficient marketing mix that attracts and engages customers, e.g., by running targeted promotions
5. Use quantitative methods and customer data to manage relationships with customers
Content
The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making.

The course is designed to be “hands-on”, with opportunities to apply skills on business cases involving real-world marketing data. It will feature guest lectures from industry experts.

The class might be taught in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned reading material for self-study.

Literature

The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.

Fostered competencies
Subject-specific Competencies: Assessed
Method-specific Competencies: Assessed
Social Competencies: Not assessed
Personal Competencies: Not assessed

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Resource Economics and Agricultural Policy

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-2903-00L</td>
<td>Evaluation of Agricultural Policies</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>R. Huber, R. Finger, C. Schader</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.</td>
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<tr>
<td>Objective</td>
<td>The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) They know the basics of how to design and implement a policy evaluation study. 3) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) They can critically assess the science-policy interface of policy evaluations.</td>
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<tr>
<td>Content</td>
<td>The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts and reading assignments</td>
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<tr>
<td>701-1651-00L</td>
<td>Environmental Governance</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>E. Lieberherr</td>
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<tr>
<td>Abstract</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Content</td>
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<tr>
<td>Lecture notes</td>
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</table>
Number of participants is limited to 30.

Priority is given to the target groups until 19.09.2022,

Target groups:
- Environmental Sciences MSc
- Agricultural Sciences MSc

Abstract
The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

Objective
To analyze how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

Content
Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of ‘environmental governance’ and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Lecture notes
Lecture slides, a script and additional course material will be provided on Moodle.

Prerequisites / notice
A detailed course schedule will be made available at the beginning of the semester.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Problem-solving</td>
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Social Competencies

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Personal Competencies

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Development and International Policy

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-2103-00L</td>
<td>Socioeconomics of Agriculture</td>
<td>W+</td>
<td>2 credits</td>
<td>2V</td>
<td>S. Mann</td>
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</table>

Abstract
The main part of this lecture will examine constellations where hierarchies, markets or cooperation have been observed and described in the agricultural sector. On a more aggregated level, different agricultural systems will be evaluated in terms of main socioeconomic parameters like social capital or perceptions.

Objective
Students should be able to describe the dynamics of hierarchies, markets and cooperation in an agricultural context.

Introduction to Sociology
Introduction to Socioeconomics
Agricultural Administration: Path dependencies and efficiency issues
Power in the Chain
The farming family
Occupational Choices
Consumption Choices
Locational Choices
Common Resource Management in Alpine Farming
Agricultural Cooperatives
Societal perceptions of agriculture
Perceptions of farming from within
Varieties of agricultural systems and policies


Lecture notes
see script
**International Aid and Development**

**W+ 2 credits 2V I. Günther**

*Does not take place this semester.*

**Prerequisites:** Basic knowledge of economics

**Abstract**

The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid. Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.

**Objective**

Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid. They are able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment.

**Content**

Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

**Literature**

Articles and book abstracts will be uploaded to a course website.

---

**International Environmental Politics**

**W+ 3 credits 2V T. Bernauer**

*Particularly suitable for students of D-ITET, D-USYS*

**Abstract**

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

**Objective**

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

**Content**

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

The lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

**Literature**

Reading materials and slides will be available via Moodle.

**Prerequisites / notice**

Basic economic knowledge is expected.

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**Political Ecology of Food and Agriculture**

**W+ 3 credits 2G J. Jacobi**

*Number of participants limited to 25*

A motivational application is required:

- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Questions regarding the application to johanna.jacobi@usys.ethz.ch.

**Abstract**

In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

**Objective**

- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

**Literature**

LITERATURE LIST PROVIDED ON MOODLE.

Moodle: https://moodle-app2.let.ethz.ch/mod/assign/view.php?id=756049
### Methodology Competences

#### Methods in Agricultural Economics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0305-00L</td>
<td>Empirical Methods in Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Tillmanns</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created videos.</td>
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<tr>
<td>Objective</td>
<td>The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.</td>
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<tr>
<td>Content</td>
<td>Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understanding of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics. The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to that, there will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.</td>
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<tr>
<td>Literature</td>
<td>Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course includes out-of-class assignments and projects to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups. Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.</td>
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<tr>
<td>363-0585-00L</td>
<td>Intermediate Econometrics</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>G. Maslorens Fuentes</td>
</tr>
<tr>
<td>Abstract</td>
<td>The aim of the course is to discuss different econometric models and their empirical applications. We will cover cross-sectional linear and non-linear regression models, models for estimating treatment effects, and linear panel data models.</td>
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<tr>
<td>Objective</td>
<td>By the end of the course, students should understand the different existing approaches, their applicability, and their advantages and disadvantages. They should be able to read and understand regression output tables. Additionally, students will be able to apply the estimation approaches in practice using STATA.</td>
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</tbody>
</table>
The lectures will consist of both theoretical and practical components. In the theoretical part, we will discuss each estimation approach in detail. The lecture will present the assumptions, derivations, as well as the advantages and disadvantages of the estimation approach.

In the empirical part, we will look at simulation results using artificial data. Furthermore, we will investigate a particular research question using STATA.

The course will tentatively cover the following subjects:
- review of ordinary least squares (OLS) estimation
- instrumental variable estimation and two-stage least squares estimation
- seemingly unrelated regression models
- simultaneous equation models
- maximum likelihood estimation
- binary response models
- count data models
- censored and truncated regression models
- sample selection models
- treatment effect models
- static linear panel data models (random effects and fixed effects estimation)

For the theoretical portions of the lectures, we will prepare slides for in-class discussion. Slides will be distributed electronically before each lecture.

For the applied portion of the lectures, we will provide STATA do files, log files, and data sets.

Problem sets will also be made available after every lecture. These problem sets will not be collected or graded, but students can use them in order to prepare for the final exam. Solutions will be made available in the following lecture.

While there is no required textbook for the course, we draw from the following texts, which are also recommend for the preparation of the exam:

**Literature**


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### 751-0423-00L Risk Analysis and Risk Management in Agriculture

**W+ 3 credits 2G R. Finger**

**Abstract**
Agricultural production is exposed to various risks and risk management is indispensable. This course introduces modern concepts on farmers’ decision making under risk and risk management. We present innovative insights, empirical example from European agriculture.

- You gain hands-on experience using R.
- to develop a better understanding of decision making under uncertainty and risk;
- gain hands-on experience in risk analysis and management using R
- to gain experience in different approaches to analyze risky decisions;
- to develop an understanding for different sources of risk in agricultural production;
- to understand the crucial role of subjective perceptions and preferences for risk management decisions;
- to get an overview on risk management in the agricultural sector, with a particular focus on insurance solutions

**Content**
- Quantification and measurement of risk
- Risk preferences, Expected Utility Theory, Cumulative Prospect Theory
- Production and input use decisions under risk
- Portfolio Theory and Farm Diversification
- Forwards, Futures, Crop Insurance
- Weather Index Insurance and Satellite Imagery
- Empirical Applications using R

**Lecture notes**
Handouts will be distributed in the lecture and available on the moodle.

**Prerequisites / notice**
knowledge of basic concepts of probability theory and microeconomics

---

### 751-1573-00L Dynamic Simulation in Agricultural and Regional Economics

**W+ 2 credits 2V B. Kopainsky**

**Abstract**
In this class, students learn the basics of system dynamics and its application to agricultural and regional economic questions. In the second half of the class, students develop their own simulation model, with which they evaluate potential interventions for improving the economic as well as the ecological sustainability of food systems.

**Objective**
- Students learn the basic theory and practice of dynamic simulation
- Students can develop, analyze and extend a dynamic simulation model and interpret its results.
- By applying the developed simulation model, students gain insights into food system issues. They also learn to recognize the benefits and pitfalls of dynamic simulation, both from a theoretical and an applied perspective.

**Lecture notes**
Slides (will be provided during the class)

**Literature**
articles and papers (will be provided during the class)

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### 363-0541-00L Systems Dynamics and Complexity

**W 3 credits 3G F. Schweitzer**

**Abstract**
Finding solutions: what is complexity, problem solving cycle.

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

**Objective**
A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics
Content

Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.

The course is structured along three main tasks:
1. Finding solutions
2. Implementing solutions
3. Controlling solutions

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as homework and two of these will be graded (see "Prerequisites").

Lecture notes

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

401-0647-00L

Introduction to Mathematical Optimization
W 5 credits 2V+1U D. Adjishvili

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature
Information about relevant literature will be given in the lecture.

Prerequisites / notice
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

363-0565-00L

Principles of Macroeconomics
W 3 credits 2V J.-E. Sturm

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
**363-1017-00L  Risk and Insurance Economics**

**W** 3 credits  2G  H. Schernberg

**Abstract**
The course covers the economics of risk and insurance, in particular the following topics will be discussed:

1) individual decision making under risk
2) models of insurance demand, risk sharing, insurance supply
3) information issues in insurance markets
4) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

**Objective**
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

**Content**
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

**Literature**
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.

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**363-1137-00L  Applied Econometrics in Environmental and Energy Economics**

**Number of participants limited to 40.**

**Abstract**
The course introduces the most common empirical methods for the analysis of issues in environmental, energy, and resource economics. The course includes computer laboratory sessions, and covers the following broad topics: demand models, discrete choice models, empirical methods in policy evaluation, field- and quasi-experiments.

**Objective**
At the end of the course, the students will be able to: understand the most common empirical methodologies used in environmental, energy, and resource economics; understand the problems the methodologies learnt in class aim to address; appreciate the importance of causal inference in empirical economics; read and understand the research papers in the literature; apply the empirical methods learnt in class using the software R.
The course introduces students to empirical statistical methods that have wide application in environmental, energy, and resource economics and it is divided in four blocks. The first block is a quick review of the basic econometric methodology and concepts (OLS, standard errors, logit/probit models); the second block introduces demand models like the Almost Ideal Demand System, discrete choice models, and their evolutions; the third block explores causal inference in empirical economics and the main reduced-form econometric techniques used in policy evaluation, such as difference-in-differences, regression discontinuity and synthetic control; the fourth block introduces field experiments and instrumental variables, and their characteristics.

At the end of each block there will be a computer laboratory class in which the student will learn to apply the methodologies learnt in class using the statistical open-source software R. Throughout the course, students will have the chance to work on actual data used for analysis in economics papers.

The lectures will make use of current research papers in the literature to illustrate practical examples in which the methodologies learnt in class have been used. Students will be expected to read in advance the paper that will be explained during the lecture.

The evaluation policy has the aim to allow students to get practical experience on the econometric methodologies learnt in class. Thus, beyond a final open-book computer exercise exam (60% of the grade), the course includes short takehome computer exercises (40% of the grade).

As the course will be centered on econometric methods, it is recommended that students have taken 363-0570-00L Principles of Econometrics first, or have otherwise a solid knowledge of basic econometric methodologies as detailed in Part 1 of Wooldridge, Jeffrey M. (2018) Introductory Econometrics : A Modern Approach. Seventh ed. ISBN: 978-1-337-55886-0. Knowledge of statistical software R is helpful, but not required and will be taught in the computer laboratory sessions.

It is highly recommended to take 363-0570-00L Principles of Econometrics first.
In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.

**Objective**
The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) They know the basics of how to design and implement a policy evaluation study. 3) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) They can critically assess the science-policy interface of policy evaluations.

**Content**
The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.

**Lecture notes**
Handouts and reading assignments

**Fostered competencies**
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Cooperation and Teamwork
- Critical Thinking

**Prerequisites / notice**
Der Praktikumsaufenthalt wird in der Regel im dritten Master-Semester, in jedem Fall vor Beginn der Master-Arbeit absolviert. Er kann erst absolviert werden, wenn
- die Bachelor-Arbeit im Studiensekretariat abgegeben wurde;
- eine Einschreibung ins Master-Studium Agrarwissenschaften erfolgt ist;
- allfällige Zulassungsaufgaben erfüllt sind.

#### Minors

**Agricultural Economics and Policy**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-2903-00L</td>
<td>Evaluation of Agricultural Policies</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>R. Huber, R. Finger, C. Schader</td>
</tr>
<tr>
<td>751-2205-00L</td>
<td>Management for Enterprises in the Agri-Food-Chain II</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>M. Weber</td>
</tr>
<tr>
<td>751-2103-00L</td>
<td>Socioeconomics of Agriculture</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>S. Mann</td>
</tr>
<tr>
<td>751-1573-00L</td>
<td>Dynamic Simulation in Agricultural and Regional Economics</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>B. Kopainsky</td>
</tr>
</tbody>
</table>

**Prerequisites / notice**
- Vorlesung "Management für Unternehmen der Agrar- & Ernährungswirtschaft I" in D-USYS

**Lecture notes**
- Vorlesung wird in deutscher Sprache abgehalten

**Fostered competencies**
Subject-specific Competencies
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Cooperation and Teamwork
- Critical Thinking

**Prerequisites / notice**
- Vorlesung wird in deutscher Sprache abgehalten

**Lecture notes**
- Vorlesung "Management für Unternehmen der Agrar- & Ernährungswirtschaft I" in D-USYS

**Literature**
- see script
- Basic economic knowledge is expected.

**Data: 01.11.2022 12:41 Autumn Semester 2022 Page 42 of 2416**
Agricultural production is exposed to various risks and risk management is indispensable. This course introduces modern concepts on farmers' decision making under risk and risk management. We present innovative insights, empirical example from European agriculture.

You gain hands-on experience using R.

Students learn the basic theory and practice of dynamic simulation. They are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.

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Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems. Responses of agroecosystems to the environment, i.e., to climate and weather events, but also to management will be studied. Different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets and carbon sequestration. Thus, students will learn about the complex interactions of a coupled human-environmental system.

Students will work with real-life data from the long-term measurement network Swiss FluxNet. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

Handouts will be available in moodle.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Critical Thinking</td>
</tr>
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<tr>
<td>assessed</td>
<td>Decision-making</td>
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<tr>
<td>assessed</td>
<td>Problem-solving</td>
<td>Self-direction and Self-management</td>
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<td>assessed</td>
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</table>

**751-3405-00L Chemical Nature of Nutrients and their Availability to Plants: The Case of Phosphorus**

**Priority will be given to students in Agricultural Sciences**

**Number of participants limited to 15.**

**Objective**

At the end of this course, participants will obtain a mechanistic understanding of why and how the speciation of phosphorus in fertilizer can affect its release to the soil solution and subsequent uptake by plants. Students will be able to use this information for the development of fertilization schemes that maximize the nutrient uptake and fertilizer efficiency of crops or pastures. During the course, participants will become familiar with the use of radioisotopes and nuclear magnetic resonance as approaches to measure nutrient availability and forms, respectively and they will know the limits of these techniques. Students will also have the opportunity to improve their laboratory, presentation, discussion and writing skills.

**Literature**

Documents will be distributed during the lecture.

**Prerequisites / notice**

The lecture will take place at the ETH experimental station in Eschikon Lindau. See the location of the station at: http://www.plantnutrition.ethz.ch/the-group/how-to-find-us.html

We strongly advise students who are planning to be absent for more than one week during the semester NOT to visit this course.

Number of participants limited to 20.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
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</tr>
<tr>
<td>assessed</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td>assessed</td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>assessed</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>not assessed</td>
</tr>
<tr>
<td>assessed</td>
<td>Project Management</td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td>assessed</td>
<td></td>
<td>Self-presentation and Social Influence</td>
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<tr>
<td>assessed</td>
<td></td>
<td>Sensitivity to Diversity</td>
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<tr>
<td>assessed</td>
<td></td>
<td>Negotiation</td>
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</table>

**751-5125-00L Stable Isotope Ecology of Terrestrial Ecosystems**

**Priority will be given to students in Agricultural Sciences**

**Number of participants limited to 20.**

**Objective**

This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small IsoProject, practice to search and analyze literature as well as to give an oral presentation.
The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

### Literature

Handouts will be available on the webpage of the course.

### Prerequisites / notice

This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies

- Analytical Competencies
- Problem-solving
- Project Management

### Social Competencies

- Communication
- Cooperation and Teamwork

### Personal Competencies

- Creative Thinking
- Self-direction and Self-management

### Objective

During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

### Content

Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).

### Lecture notes

None

### Literature

Peer-reviewed research articles, selected according to the topic.

### Prerequisites / notice

Participation in the BSc course 'Pflanzenzüchtung' is strongly recommended, a completed course in 'Molecular Plant Breeding' is advantageous.

#### Agronomy and Plant Breeding

This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can no longer be chosen. The course units offered in the minor can still be taken as electives.

### Number

751-4104-00L

### Title

Alternative Crops

### Type

W

### ECTS

2 credits

### Hours

2V

### Lecturers

A. Walter, K. Berger Büter

### Abstract

Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

### Objective

During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

### Content

Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).

### Lecture notes

None

### Literature

Peer-reviewed research articles, selected according to the topic.

### Prerequisites / notice

Participation in the BSc course 'Pflanzenzüchtung' is strongly recommended, a completed course in 'Molecular Plant Breeding' is advantageous.

#### Animal Sciences

This minor is new and in force from the academic year 22/23. The complete courselist for this minor will be published on the website of the Study Programme.

### Number

751-6001-00L

### Title

Forum: Livestock in the World Food System

### Type

W+

### ECTS

2 credits

### Hours

1S

### Lecturers

S. Meese

### Abstract

This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.

### Objective

In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society.). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.
The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

**Part 1**
- Aspect 1 - Oral presentation: The students form small groups and are lecturers.
- Aspect 2 - chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
- Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

**Part 2.**
- Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
- Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Introductions to both presentation forms will be given by the lecturer.

**Lecture notes**

**Prerequisites / notice**

Requirements for allocation of the two credit points:

- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)

- Feedback on the presentation style of a student

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**751-6501-00L**

**Ruminant Science**

*Abstract*

The course provides the scientific basis of the central aspects of reproduction and nutrition physiology of ruminants, and of the implications for animal health, product quality, and breeding programs. Means of knowledge transfer include interdisciplinary approaches, disciplinary parts, web-based learning and self-study.

*Objective*

At the end of the course the students are able to apply, by a comprehensive understanding of the underlying mechanisms, their knowledge in various fields of ruminant science. They will be able to develop and recommend best strategies for breeding programs, feed formulation, improving forage quality, and increasing animal health. They will be trained to carry out interdisciplinary and disciplinary research at the highest level.

*Content*

**Fields (contact hours)**
- Introduction: 2 h
- Special topics: 20 h
- Rumen Anatomy
- Hohenheim Gas Test
- Call health
- Reproduction Techniques
- Fertility in Cows
- Disciplinary topics: 32 h
- Rumenal Digestion: 8 h
- Ruminant Nutrition Physiology: 12 h
- Reproduction in Ruminants: 8 h
- Lectures held by the students: 4 h

In summary
- Contact hours: 58 h
- Self-study within semester: 30 h (especially preparation for the interdisciplinary courses and the own lecture)
- Self-study in semester break: 32 h
Total: 120 h

*Lecture notes*

Documentations, links and other materials will be provided at the start of the course.

*Literature*

Information on books and other references will be communicated during the course.

*Prerequisites / notice*

The specialty of this course is that for the first time the animal science disciplines are unified. This is realised with a particular emphasis on interdisciplinary special topics and new forms of teaching. At the same time the essential basics in the central fields are communicated.

Conditions for successful participation: Background on animal science from the Bachelor is desired. In order to attend the Minor in Ruminant Science without any animal science background, a realistic self-assessment concerning the need for additional self-study is recommended (e.g. by choosing an appropriate bachelor course which then may be counted as ‘optional courses’ in the master). These efforts depend on the extent to which animal science courses have already been attended in the bachelor.

The control of performance will consist of:
- an own short lecture
- a final oral examination with focus on comprehension of the fundamental linkages rather than of specific details

---

**751-6243-00L**

**Breeding and Conservation of Animal Genetic Resources**

*Abstract*

Animal genetic resources refer to the genetic and species diversity of livestock. Only a few production breeds have been further developed through breeding, while local breeds have no longer been able to survive in this competition. Without the support of endangered breeds and the sustainable breeding of productive breeds, many regionally typical breeds are threatened with extinction.
Objective Learning Objectives: Part 1:
At the end of the course, students are able to assess the importance and problems of small ruminant breeding and husbandry in Switzerland and neighbouring countries. They know the most important breeding objectives and are able to assess them in terms of production and sustainable development in small ruminants and cattle.

Learning objectives part 2:
The second part gives an overview of the distribution, endangerment and conservation of breed diversity of farm animals in Switzerland and internationally. The theory is illustrated with numerous examples and the knowledge is deepened in exercises.

The students:
- have an overview of the national and international distribution of animal genetic resources and are familiar with the database DAD-IS (Domestic Animal Diversity Information System).
- can name the national and international efforts to conserve agricultural livestock breeds.
- know how to describe genetic diversity.
- can point out what is important in the management of small populations.
- can describe different conservation measures, especially in situ and ex situ conservation.
- can describe current national and international conservation programmes for different livestock breeds.

Prerequisites / notice
Examination:
Examination Part 1: Graded written examination (1 hour) on the material covered.
Examination Part 2: Graded semester performance completed during the block course.
Parts 1 and 2 contribute equally to the final grade.

Crop- and Grassland Science
This minor is new and in force from the academic year 22/23. The complete course list for this minor will be published on the website of the Study Programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-4104-00L</td>
<td>Alternative Crops</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Walter, K. Berger Büter</td>
</tr>
<tr>
<td>Abstract</td>
<td>Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.</td>
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<tr>
<td>Objective</td>
<td>Students will understand the consequences arising from the unintentional or deliberate introduction of alien organisms into agricultural systems. They will be able to understand the concept of environmental risk assessment and be able to evaluate risk management options.</td>
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</table>

- Establishing contacts and strengthening the network to national and international plant breeders and scientist
- Critical evaluation and consolidation of the acquired knowledge in an interdisciplinary team
- Independent literature research to get familiar with the selected topic
- Critical evaluation of current activities, latest achievements and future prospective of a selected topic/area in plant breeding.

Content
Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).

Lecture notes
None

Literature
Peer-reviewed research articles, selected according to the topic.

Prerequisites / notice
Participation in the BSc course ‘Pflanzenzüchtung’ is strongly recommended, a completed course in ‘Molecular Plant Breeding’ is advantageous.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>751-3603-00L</td>
<td>Current Challenges in Plant Breeding</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>B. Studer, A. Hund, R. Kölliker</td>
</tr>
<tr>
<td>Number of participants limited to 15.</td>
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<tr>
<td>Abstract</td>
<td>The seminar ‘Current challenges in plant breeding’ aims to bring together national and international experts in plant breeding to discuss current activities, latest achievements and future prospective of a selected topic/area in plant breeding.</td>
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<tr>
<td>Objective</td>
<td>The educational objectives cover thematic, methodic as well as social and personal competencies:</td>
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<td></td>
<td>Thematic/methodic competencies:</td>
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<tr>
<td></td>
<td>Deepening of scientific knowledge in plant breeding</td>
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<tr>
<td></td>
<td>Critical evaluation of current challenges and new concepts in plant breeding</td>
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<td></td>
<td>Promotion of collaboration and Master thesis projects with practical plant breeders</td>
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<tr>
<td>Social/personal competencies:</td>
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<td></td>
<td>Independent literature research to get familiar with the selected topic</td>
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<td></td>
<td>Critical evaluation and consolidation of the acquired knowledge in an interdisciplinary team</td>
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<tr>
<td>Content</td>
<td>Establishment of a scientific presentation in an interdisciplinary team</td>
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<tr>
<td></td>
<td>Presentation and discussion of the teamwork outcome</td>
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<tr>
<td></td>
<td>Establishing contacts and strengthening the network to national and international plant breeders and scientist</td>
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</tbody>
</table>

Learning objectives part 2:
- can describe current national and international conservation programmes for different livestock breeds.
- can describe different conservation measures, especially in situ and ex situ conservation.
- can describe current national and international conservation programmes for different livestock breeds.

Lecture notes
Material will be distributed during the course.

Prerequisites / notice
A part of the course will take place in flipped classroom mode, i.e. the lectures on 27.9., 18.10., 25.10., 15.11. and 22.11. will be available as podcasts.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>751-5101-00L</td>
<td>Biogeochemistry and Sustainable Management</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>N. Buchmann, I. Feigenwinter, V. Klaus</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems.</td>
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<tr>
<td>Objective</td>
<td>Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems, be able to analyze large meteorological and flux data sets, and evaluate the impacts of weather events and management practices, based on real-life data. Moreover, students will be able to coordinate and work successfully in small (interdisciplinary) teams.</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 47 of 2416
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems. Responses of agroecosystems to the environment, i.e., to climate and weather events, but also to management will be studied. Different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets and carbon sequestration. Thus, students will learn about the complex interactions of a coupled human- environmental system.

Students will work with real-life data from the long-term measurement network Swiss FluxNet. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and current topics in agro- and forest ecosystem sciences.

The presentations will be synthesized during a final discussion. The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is “Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments”. The students will analyze and connect the results published (or from data records) for selected field experiments in a group work. They will present their analysis in a report and in an oral presentation. The seminar is composed by presentations of experts and of the students. The presentations will be synthesized during a final discussion.

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Crop Health

This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can not longer be chosen. The course units offered in the minor can still be taken as electives.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
</tr>
<tr>
<td>751-4811-00L</td>
<td>Alien Organisms in Agriculture</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>J. Collatz, M. Meissle</td>
</tr>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
<tr>
<td>751-4506-00L</td>
<td>Plant Pathology III</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>M. Maurhofer Bringolf</td>
</tr>
</tbody>
</table>

Abstract:
The students will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes lectures, small group discussions and outside readings.

Objective:
The aim of the course is to gain an understanding of how insects have specialised and adapted to occupy diverse environmental niches and become vital to ecosystem processes. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions and examining insect ecology in an evolutionary context.

Content:
Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.

Prerequisites:
A part of the course will take place in flipped classroom mode, i.e. the lectures on 27.9., 18.10., 25.10., 15.11. and 22.11. will be available as podcasts.

Number of participants limited to 20.

751-4506-00L

Abstract:
Identification based on hosts, symptoms and micro-morphology, completed with life cycles and related control measures of the most important fungal diseases and their causal pathogens of annual and perennial crops with agricultural significance.

Objective:
The students will learn and train preparation skills for microscopy, acquire knowledge of selected diseases (identification, biology of pathogen, epidemiology and systematics) and understand the corresponding integrated control measures practiced in Swiss agriculture.

Content:
One exercise will be on an e-learning base (with computers) also to prepare the students for the final e-exam.

Lecture notes:
A script will be used on annual and perennial crops and their most important diseases. It will be updated stepwise.

Prerequisites:
The course will be in German (spec. nomenclature).

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Critical Thinking

Assessed:
- Field Competencies

References:
- J. Collatz
- C. De Moraes
- W

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 49 of 2416
Data Science and Technology for Agricultural Science

Number Title Type ECTS Hours Lecturers
701-3001-00L Environmental Systems Data Science: Data Processing W+ 2 credits 2G L. Pellissier, E. J. Harris, J. Payne, M. Volpi

Number of participants is limited to 80.

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022.

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
- 252-0840-02L Anwendungsnahes Programmieren mit Python
- 401-6215-00L Using R for Data Analysis and Graphics (Part I)
- 701-0105-00L Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

401-6215-00L Using R for Data Analysis and Graphics (Part I) W+ 1.5 credits 1G M. Mächler

Abstract
The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

Objective
The students will be able to use the software R for simple data analysis and graphics.

Content
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

Lecture notes
- An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
- The course resources will be provided via the Moodle web learning platform.
- Subscribing via Mystudies *automatically* makes you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=18279
Autonomous robots are quickly becoming a key player in the transition to precision agriculture. In this course, students will learn theoretical methods and techniques for using robots in agriculture. The students will be able to use the software R efficiently for data analysis, graphics, and simple programming.

**Objective**
The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options;
- Extending basic R: packages

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

**Lecture notes**
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

**Prerequisites / notice**
Basic knowledge of R equivalent to "Using R... (Part I)" (W 401-6215-00L) is a prerequisite for this course.

**Content**
The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should *automatically* make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15522
### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
<td>not assessed</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
<td>not assessed</td>
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### 701-0951-00L GIS - Introduction into Geoinformation Science and Technology

**Number of participants limited to 75. Waiting list will be deleted 07.10.2022.**

**Abstract**

Theoretical basics and fundamental concepts of Geographic Information Science (GIS) are imparted and subsequently further elaborated with the software ArcGIS.

At the end, the students will be able to independently solve basic realistic GIS problems.

**Objective**

Students are able to
- elucidate the theoretical and conceptional foundations of geographic information systems (GIS)
- independently perform normal GIS work using commercial software and practical examples

**Content**

The course covers the following topics:
- What is GIS? What are spatial data?
- The representation of reality by means of spatial data models: vector, raster, TIN
- The four phases of data modelling: Spatial, conceptual, logical and physical model
- Possibilities of data collection
- Transition of reference frame
- Spatial Analysis I: query and manipulation of vector data
- Spatial Analysis II: operators and functions with raster data
- Digital elevation models and derived products
- Process modelling with vector and raster data
- Presentation possibilities of spatial data

One Friday is reserved for a field trip or guest speaker;

**Literature**


John Wiley & Son, Ltd. Chichester.


**Prerequisites / notice**

Aufgrund der Grösse des verfügbaren EDV-Schulungsraumes ist die Teilnehmerzahl auf 50 Studierende beschränkt! Für die Übungen werden die Studierenden auf zwei, max. drei Zeitfenster aufgeteilt. Pro Zeitfenster können maximal 25 Studierende betreut werden.

### 651-4031-00L Geographic Information Systems

**Number of participants limited to 60.**

**Abstract**

Introduction to the architecture and data processing capabilities of geographic information systems (GIS). Practical application of spatial data modeling and geoprocessing functions to a selected project from the earth sciences.

**Objective**

Knowledge of the basic architecture and spatial data handling capabilities of geographic information systems.

**Content**

Theoretical introduction to the architecture, modules, spatial data types and spatial data handling functions of geographic information systems (GIS). Application of data modeling principles and geoprocessing capabilities using ArcGIS: Data design and modeling, data acquisition, data integration, spatial analysis of vector and raster data, particular functions for digital terrain modeling and hydrology, map generation and 3D-visualization.

**Lecture notes**

Introduction to Geographic Information Systems, Tutorial: Introduction to ArcGIS Pro

**Literature**


### 701-3003-00L Environmental Systems Data Science: Machine Learning

**Number of participants is limited to 80.**

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

**Target groups**

- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc

Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc

L. Pellissier, E. J. Harris, J. Payne, M. Volpi
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning models on existing datasets.

Objective
The students are able to:
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature
Building on existing data science resources

Prerequisites
Math IV, VI (Statistics); R, Python; ESDS I

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>751-5115-00L</td>
<td>Current Aspects of Nutrient Cycle in Agro-Ecosystems</td>
<td>W</td>
<td>2 credits</td>
<td>1S</td>
<td>E. Frossard, A. Oberson Dräyer</td>
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Abstract
The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is “Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments”.

Objective
Analyze publications and/or data records on long-term field experiments regarding their content on integrated nutrient management and derive the nutrient use efficiency; link this information, write it up in a report and present the results in an oral presentation; work in a group; ask questions and contribute to the discussion following the oral presentations; link the information to overarching questions and recommendations; expand the knowledge on nutrient cycles and nutrient management in the agro-ecosystem; learn about the importance of long-term field experiment to answer questions on the sustainability of agricultural systems.

Content
The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is “Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments”. The students will analyze and connect the results published (or from data records) for selected field experiments in a group work. They will present their analysis in a report and in an oral presentation. The seminar is composed by presentations of experts and of the students. The presentations will be synthesized during a final discussion.

Fostered competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

751-3405-00L    | Chemical Nature of Nutrients and their Availability to Plants: The Case of Phosphorus | W    | 4 credits | 4G    | E. Frossard, L. P. Schönholzer, M. Wiggenhauser |

Priority will be given to students in Agricultural Sciences

Abstract
The course discusses the mechanistic relationships between nutrient speciation in fertilizer and nutrient uptake by plants using phosphorus as an example. The course involves theoretical aspects of nutrient cycling, laboratory work, data analysis and presentation, and the use of advanced methods in plant nutrition studies.

Objective
At the end of this course, participants will obtain a mechanistic understanding of why and how the speciation of phosphorus in fertilizer can affect its release to the soil solution and subsequent uptake by plants. Students will be able to use this information for the development of fertilization schemes that maximize the nutrient uptake and fertilizer efficiency of crops or pastures. During the course, participants will become familiar with the use of radioisotopes and nuclear magnetic resonance as approaches to measure nutrient availability and forms, respectively and they will know the limits of these techniques. Students will also have the opportunity to improve their laboratory, presentation, discussion and writing skills.

Lecture notes
Documents will be distributed during the lecture.

Literature
Documents will be distributed during the lecture.
Stable Isotope Ecology of Terrestrial Ecosystems

**Prerequisites**
- The course will take place at the ETH experimental station in Eschikon Lindau. See the location of the station at: http://www.plantnutrition.ethz.ch/the-group/how-to-find-us.html
- We strongly advise students who are planning to be absent for more than one week during the semester NOT to visit this course.
- Students must have visited the plant nutrition lectures in the 3rd and 6th semesters and the lecture pedosphere in the 3rd semester of the agricultural study program of the ETH (or bring an equivalent knowledge). This knowledge is indispensable for this 7th semester.

**Objective**
- Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small IsoProject, practice to search and analyze literature as well as to give an oral presentation.
- The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.
- This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

**Content**
- Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.
- The course "Soil and Water Chemistry" teaches, applies and examines the competences process understanding, systems understanding, and modelling.

**Literature**
- –Chapters 1, 3, 4, 6, 7 and 11 in Sigg/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016.

**Prerequisites / notice**
- This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.
- Number of participants limited to 20.
- Students must have visited the plant nutrition lectures in the 3rd and 6th semesters and the lecture pedosphere in the 3rd semester of the agricultural study program of the ETH (or bring an equivalent knowledge). This knowledge is indispensable for this 7th semester.
- The lecture will take place at the ETH experimental station in Eschikon Lindau. See the location of the station at: http://www.plantnutrition.ethz.ch/the-group/how-to-find-us.html
- We strongly advise students who are planning to be absent for more than one week during the semester NOT to visit this course.
- Students must have visited the plant nutrition lectures in the 3rd and 6th semesters and the lecture pedosphere in the 3rd semester of the agricultural study program of the ETH (or bring an equivalent knowledge). This knowledge is indispensable for this 7th semester.

**Subject-specific Competencies**
- Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies assessed
- Decision-making not assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed
- Adaptability and Flexibility not assessed
- Creative Thinking not assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

**Social Competencies**
- Personal Competencies
- Handouts will be available on the webpage of the course.
- This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

**Method-specific Competencies**
- Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies assessed
- Decision-making not assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed
- Adaptability and Flexibility not assessed
- Creative Thinking not assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

**Personal Competencies**
- Handouts will be available on the webpage of the course.
- This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

**Autumn Semester 2022**
The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

**Objective**

- characterize porous media at different scales
- parameterize structural, flow, and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils

**Content**

Week 1 (September 21): Introduction, content, structure of the course, objectives, bibliography, grading and evaluation; soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density.

Week 2 (September 28): Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation; surface tension; Young-Laplace equation; capillary rise; contact angle.

Week 3 (October 5): Friction and laminar flow; Hagen-Poiseuille’s law; Washburn equation; numerical lab (including report)

Week 4 (October 12): Soil water content; soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point.

Week 5 (October 19): Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; Demo lab (including report)

Week 6 (October 26): Saturated water flow in soils - Laminar flow in tubes (Poiseuille’s Law); Darcy’s Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman); effective conductivity; unsaturated hydraulic conductivity; Buckingham law.

Week 7 (November 2): Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8 (November 9): Numerical solution of Richards equation – Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)

Week 9 (November 16): Solute and gas transport in soils - Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 9 (November 23): Conductivity and resistance of soils – differences and similarities of hydraulic, electrical, thermal conductivities; Buckingham-Darcy, Fourier, and Archie’s law; pore scale characteristics and effective conductivities; soil thermal properties; steady state and non-steady heat flow

Week 11 (November 30): Energy balance and land atmosphere interactions - Radiation and energy balance; evapotranspiration, potential and actual evaporation, definitions and estimation; evaporation stages and characteristic length

Week 12 (December 7): Root water uptake and transpiration – Mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance

Week 13 (December 14): Summary, questions, old exam

**Literature**

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hilker

**Prerequisites / notice**

Vadose Zone Hydrology/Environmental Soil Physics (recommended but not required)
Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).

Adaptability and Flexibility

The seminar 'Current challenges in plant breeding' aims to bring together national and international experts in plant breeding to discuss various subjects from Food security, climate mitigation, agroecology, resilience to soil physics or agricultural economics. Students will engage in readings, discussions and exchanges on the specifics of tropical agriculture.

On, students gain practical knowledge on field - An integral part of the course is the two-week field project in a Tropical region, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

On the second module, students gain practical knowledge on field - An integral part of the course is the two-week field project in Kenya, conducting various assessments related to Food and Energy Security.

We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 23rd 2022, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can no longer be chosen. The course units offered in the minor can still be taken as electives.

General Crop Science

This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can no longer be chosen. The course units offered in the minor can still be taken as electives.

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<tbody>
<tr>
<td>751-4104-00L</td>
<td>Alternative Crops</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Walter, K. Berger Büter</td>
</tr>
<tr>
<td>Abstract</td>
<td>Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.</td>
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<tr>
<td>Objective</td>
<td>During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.</td>
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<td>751-3603-00L</td>
<td>Current Challenges in Plant Breeding</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>B. Studer, A. Hund, R. Kölliker</td>
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<tr>
<td>Abstract</td>
<td>The seminar 'Current challenges in plant breeding' aims to bring together national and international experts in plant breeding to discuss current activities, latest achievements and future perspective of a selected topic/area in plant breeding.</td>
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<tr>
<td>Objective</td>
<td>The educational objectives cover thematic, methodic as well as social and personal competencies: Thematic/methodic competencies: - Deepening of scientific knowledge in plant breeding - Critical evaluation of current challenges and new concepts in plant breeding - Promotion of collaboration and Master thesis projects with practical plant breeders Social/personal competencies: - Independent literature research to get familiar with the selected topic - Critical evaluation and consolidation of the acquired knowledge in an interdisciplinary team - Establishment of a scientific presentation in an interdisciplinary team - Presentation and discussion of the teamwork outcome - Establishing contacts and strengthening the network to national and international plant breeders and scientist</td>
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<td>Content</td>
<td>Interesting topics related to plant breeding will be selected in close collaboration with the working group for plant breeding of the Swiss Society of Agronomy (SSA).</td>
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<tr>
<td>Lecture notes</td>
<td>None</td>
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<tr>
<td>Literature</td>
<td>Peer-reviewed research articles, selected according to the topic.</td>
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<td>Prerequisites / notice</td>
<td>Participation in the BSc course 'Pflanzenzüchtung' is strongly recommended, a completed course in 'Molecular Plant Breeding' is advantageous.</td>
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751-4704-00L Weed Science W 3 credits 2G B. Streit, U. J. Haas
Abstract Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.

Objective At the end of the course the students are qualified to develop sustainable solutions for weed problems in agricultural and natural habitats.

Content Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.

751-5121-00L Insect Ecology

Abstract This is an introductory class on insect ecology. During the course you will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes lectures, small group discussions and outside readings.

Objective The aim of the course is to gain an understanding of how insects have specialised and adapted to occupy diverse environmental niches and become vital to ecosystem processes. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions and examining insect ecology in an evolutionary context.

Lecture notes Provided to students through Moodle

Literature Selected required readings (peer reviewed literature). Optional recommended readings with additional information.

751-4811-00L Alien Organisms in Agriculture

Abstract The course focuses on alien organisms in agriculture as well as the scientific assessment and regulatory management of their effects on the environment and agricultural production.

Objective Students will understand the consequences arising from the unintentional or deliberate introduction of alien organisms into agricultural systems. They will be able to understand the concept of environmental risk assessment and be able to evaluate risk management options.

Content Alien organisms in agriculture is a topic that receives an increasing awareness among farmers, agricultural scientists, regulators and the general public. Students of this course will learn about the nature of alien organisms such as invasive species, biocontrol organisms and genetically modified organisms. With a particular focus on arthropods, plants and their interactions we will look at the potential threats the novel organisms pose, the benefits they provide and how both of these effects can be scientifically assessed. Students will learn how the topic of alien organisms in agriculture is intrinsically tied to policy making and regulation and get to know current examples and future challenges in research. In the last part of the course students will be able to apply the acquired knowledge in a practical exercise (case study).

Lecture notes Material will be distributed during the course

Prerequisites / notice A part of the course will take place in flipped classroom mode, i.e. the lectures on 27.9., 18.10., 25.10., 15.11. and 22.11. will be available as podcasts.

701-0263-01L Seminar in Evolutionary Ecology of Infectious Diseases

Abstract Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

Objective This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

Content A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

Lecture notes Literature

Publications and class notes can be downloaded from a web page announced during the lecture. Papers will be assigned and downloaded from a web page announced during the lecture.

751-4506-00L Plant Pathology III

Abstract Identification based on host, symptoms and micro-morphology, completed with life cycles and related control measures of the most important fungal diseases and their causal pathogens of annual and perennial crops with agricultural significance.

Objective The students will learn and train preparation skills for microscopy, acquire knowledge of selected diseases (identification, biology of pathogen, epidemiology and systemsatics) and understand the corresponding integrated control measures practiced in Swiss agriculture.

Content One exercise will be on an e-learning base (with computers) also to prepare the students for the final e-exam.

Lecture notes The course will be used on annual and perennial crops and their most important diseases. It will be updated stepwise

Fostered competencies Subject-specific Competencies Concepts and Theories Techniques and Technologies

Method-specific Competencies Analytical Competencies Problem-solving

Personal Competencies Critical Thinking

751-5101-00L Biogeochemistry and Sustainable Management

Abstract This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems.

Objective Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems, be able to analyze large meteorological and flux data sets, and evaluate the impacts of weather events and management practices, based on real-life data. Moreover, students will be able to coordinate and work successfully in small (interdisciplinary) teams.
Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems. Responses of agroecosystems to the environment, i.e., to climate and weather events, but also to management will be studied. Different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets and carbon sequestration. Thus, students will learn about the complex interactions of a coupled human-environmental system.

Students will work with real-life data from the long-term measurement network Swiss FluxNet. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

**Content**

**Lecture notes**
Handouts will be available in moodle.

**Prerequisites / notice**
Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.

**Fostered competencies**

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<td>Concepts and Theories</td>
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<td>Method-specific Competencies</td>
<td>Decision-making</td>
<td>Self-direction</td>
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<td>and Self-management</td>
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<tr>
<td>assessed</td>
<td>Problem-solving</td>
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**Literature**
Documents will be distributed during the lecture.

**Prerequisites / notice**
Documents will be distributed during the lecture.

**Objective**
At the end of this course, participants will obtain a mechanistic understanding of why and how the speciation of phosphorus in fertilizer can affect its release to the soil solution and subsequent uptake by plants. Students will be able to use this information for the development of fertilization schemes that maximize the nutrient uptake and fertilizer efficiency of crops or pastures. During the course, participants will become familiar with the use of radioisotopes and nuclear magnetic resonance as approaches to measure nutrient availability and forms, respectively and they will know the limits of these techniques. Students will also have the opportunity to improve their laboratory, presentation, discussion and writing skills.

**Literature**

- Handouts will be available in moodle.
- The course will take place at the ETH experimental station in Eschikon Lindau. See the location of the station at: http://www.plantnutrition.ethz.ch/the-group/how-to-find-us.html
- We strongly advise students who are planning to be absent for more than one week during the semester NOT to visit this course.
- Documents will be distributed during the lecture.

**Fostered competencies**

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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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**Literature**
Documents will be distributed during the lecture.

**Objective**
This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to track and integrate processes. In addition, students carry out a small project during lab sessions.

**Fostered competencies**

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<tr>
<th>Subject-specific Competencies</th>
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<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tr>
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</table>

**Literature**
Documents will be distributed during the lecture.

**Objective**
Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small ISOProject, practice to search and analyze literature as well as to give an oral presentation.
The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

Handouts will be available on the webpage of the course.

The seminar concerns current aspects and research related to nutrient cycles in agro-ecosystems. The theme of the next seminar is "Integrated Nutrient Management to maximize nutrient use efficiency in productive agricultural systems: Insights from long-term field experiments". The students will analyze and connect the results published (or from data records) for selected field experiments in a group work. They will present their analysis in a report and in an oral presentation. The seminar is composed by presentations of experts and of the students. The presentations will be synthesized during a final discussion.
strongly recommended to verify with lecturers from other courses whether their absence of two weeks may affect their performance in the respective courses.

Abstract
This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in Ethiopia, which is co-organized with Eldoret University (Kenya) and KU Leuven (Belgium).

Objective
(1) Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
(2) Interdisciplinary analysis of agricultural production systems
(3) Knowledge on methods to assess agroecological performance of a tropical agroecosystems
(4) Hands-on training on the use of field methods, diagnostic tools and survey methods.
(5) Gain practical knowledge on how to assess to climate resilience and farming systems.
(6) Collaboration in international students and stakeholders

Content
This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, climate mitigation, agroecology, resilience to soil physics or agricultural economics. Students will engage in readings, discussions and exchanges on the specificities of tropical agriculture. On, students gain practical knowledge on field - An integral part of the course is the two-week field project in a Tropical region, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

Prerequisites / notice
We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 23rd 2022, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tbody>
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<td>Negotiation</td>
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</table>

| Personal Competencies                  |          |
| Adaptability and Flexibility           |          |
| Critical Thinking                      |          |
| Integrity and Work Ethics              |          |
| Self-awareness and Self-reflection     |          |
| Self-direction and Self-management     |          |

751-2105-00L Political Ecology of Food and Agriculture

W 3 credits 2G J. Jacobi

Number of participants limited to 25
A motivational application is required:
- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Abstract
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective
- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Literature
Literaturelist provided on Moodle.

Moodle: https://moodle-app2.let.ethz.ch/mod/assign/view.php?id=756049
The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it will be assessed by the students and the remaining students and the lecturer are the audience and ask questions.

Learning Objectives: Part 1:
- have an overview of the national and international distribution of animal genetic resources and are familiar with the database DAD-IS (Domestic Animal Diversity Information System).
- can name the national and international efforts to conserve agricultural livestock breeds.
- can point out what is important in the management of small populations.
- can describe different conservation measures, especially in situ and ex situ conservation.
- can describe current national and international conservation programmes for different livestock breeds.

Learning objectives part 2:

The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

Part 1
Aspect 1 - Oral presentation: The students form small groups and are lecturers.
Aspect 2 - chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

Part 2
Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Introduction to both presentation forms will be given by the lecturer.

Number of participants limited to 20.

Prerequisites:
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)
- Feedback on the presentation style of a student

The students:
- can describe current national and international conservation programmes for different livestock breeds.
- can describe different conservation measures, especially in situ and ex situ conservation.
- can point out what is important in the management of small populations.
- can describe genetic diversity.
- can name different conservation measures, especially in situ and ex situ conservation.
- can describe current national and international conservation programmes for different livestock breeds.

Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.

The second part gives an overview of the distribution, endangerment and conservation of breed diversity of farm animals in Switzerland and internationally. The theory is illustrated with numerous examples and the knowledge is deepened in exercises.

The lectures are given in the second part of the course units offer.

The course units offered in the minor can still be taken as electives.

This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can no longer be chosen. The course units offered in the minor can still be taken as electives.
**Principles of Livestock Systems**

This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can no longer be chosen. The course units offered in the minor can still be taken as electives.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>751-6243-00L</td>
<td>Breeding and Conservation of Animal Genetic Resources</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>H. Signer-Hasler, C. Flury, S. Neuenschwander</td>
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**Abstract**

Animal genetic resources refer to the genetic and species diversity of livestock. Only a few production breeds have been further developed through breeding, while local breeds have no longer been able to survive in this competition. Without the support of endangered breeds and the sustainable breeding of productive breeds, many regionally typical breeds are threatened with extinction.

**Objective**

Learning Objectives: Part 1:

At the end of the course, students are able to assess the importance and problems of small ruminant breeding and husbandry in Switzerland and neighbouring countries. They know the most important breeding objectives and are able to assess them in terms of production and sustainable development in small ruminants and cattle.

Learning objectives part 2:

The second part gives an overview of the distribution, endangerment and conservation of breed diversity of farm animals in Switzerland and internationally. The theory is illustrated with numerous examples and the knowledge is deepened in exercises.

The students:
- have an overview of the national and international distribution of animal genetic resources and are familiar with the database DAD-IS (Domestic Animal Diversity Information System),
- can name the national and international efforts to conserve agricultural livestock breeds,
- know how to describe genetic diversity,
- can point out what is important in the management of small populations,
- can describe different conservation measures, especially in situ and ex situ conservation,
- can describe current national and international conservation programmes for different livestock breeds.

**Prerequisites / notice**

Examination:
- Examination Part 1: Graded written examination (1 hour) on the material covered.
- Examination Part 2: Graded semester performance completed during the block course.
- Parts 1 and 2 contribute equally to the final grade.

751-6127-00L | Practical Course in Microscopy of Functional Histology                | W    | 3    | 6P    | not available       |

**Abstract**

Die "Funktionelle Histologie" beschreibt die histologischen und zytologischen Strukturen mit ihren jeweiligen Aufgaben und Wechselwirkungen innerhalb ausgewählter Organsysteme. Die endokrinologisch relevanten Organe und deren Präparation werden am Beispiel des Rindes kennengelernt.

**Objective**

Grundlagen der Histologie; Gewebedünnschnitte (Gefrier- und Paraffinschnitte) und deren Übersichtsfärbungen und Immunhistochemie; Fortgeschrittene Mikroskopie von Gewebedünnschnitten; Kritische Bewertung von Physiologie/Pathologie aufgrund morphologisch/histologischer Kriterien.
### Practical Course Epigenetics

**Abstract**
The practical course will comprise of lecture elements introducing the topic of epigenetics and a large amount of practical work where you will be able to perform DNA methylation analyses on your own. In particular, we will focus on DNA extraction and the estimation of global and local DNA methylation.

**Objective**
The competencies and aims for the course are:
- Get first-hand experience with the experimental techniques.
- Answer a scientific question by conducting experiments.
- Obtain results of an experiment and get insight into what affects technical variation and thus influences reproducibility.
- Interpret results in an adequate manner to solve a scientific question.
- Combine results to draw an adequate conclusion.
- Present a research paper on epigenetics.

**Lecture notes**
You will receive in advance a selection of research papers, a document with the theoretical background of the techniques included in the course, the slides of the lessons in pdf and a detailed protocol of the work we will do.

**Prerequisites**

**Content**
- basic principles of genetic evaluations
- Applied genetic evaluation in cattle (data, methods, traits, national and international genetic evaluations)
- Applied genetic evaluation in pigs (data, methods, traits)
- Applied genetic evaluation in sheep and goats (data, methods, traits)

**Literature**
Course notes in the form of a monograph, copies of the slides and solutions to the exercise questions are available on the net.

**ECTS** 3 credits

**W** 4 credits

**6P** not available

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### Livestock Breeding and Genomics

**Abstract**
Swiss routine breeding value estimation/genetic evaluation systems of cattle, pig, sheep and goats are presented with methods and procedures. The students will be able to perform DNA methylation analyses on their own.  In particular, we will focus on DNA extraction and the estimation of global and local DNA methylation.

**Objective**

**Prerequisites**

**Content**
- basic principles of genetic evaluations
- Applied genetic evaluation in cattle (data, methods, traits, national and international genetic evaluations)
- Applied genetic evaluation in pigs (data, methods, traits)
- Applied genetic evaluation in sheep and goats (data, methods, traits)

**Literature**
Course notes in the form of a monograph, copies of the slides and solutions to the exercise questions are available on the net.

**ECTS** 3 credits

**W** 4 credits

**6P** not available

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### Endocrinology and Biology of Reproduction

**Abstract**
Endokrinologie und Reproduktionsbiologie der Säugetiere und des Menschen (Anatomie, Morphologie, Physiologie, Regelmechanismen) werden vorgestellt. Die Systematik der Reproduktionshormone und der Hormonrezeptoren wird erläutert, die Wirkungsmechanismen (Bildung; orale Bioverfügbarkeit; Elimination) erklärt. Mit diesen Grundlagen wird das Verständnis der Regulation der Fortpflanzung umfassend erörtert. Die Studierenden erlangen das grundlegende theoretische Verständnis und Fachwissen zur Endokrinologie der Reproduktion und zur weiblichen und männlichen Reproduktionsbiologie. Sie können darüber hinaus pathologische Situationen (Fortpflanzungsstörungen) und deren vielfältige Ursachen in den physiologischen Kontext einordnen.

**Objective**

**Ruminant Science**

This minor will only be offered in the academic year 22/23. As of the academic year 23/24, the minor can no longer be chosen. The course units offered in the minor can still be taken as electives.

**Number**

**Title**

**Type**

**ECTS**

**Hours**

**Lecturers**

**Data:** 01.11.2022 12:41

**Autumn Semester 2022**

**Page 63 of 2416**
Content
Fields (contact hours)
- Introduction: 2 h
- Special topics: 20 h
  - Rumen Anatomy
  - Hohenheim Gas Test
  - Calf health
  - Reproduction Techniques
  - Fertility in Cows
  - Disciplinary topics: 32 h
  - Ruminal Digestion: 8 h
  - Ruminant Nutrition Physiology: 12 h
  - Reproduction in Ruminants: 8 h
- Lectures held by the students: 4 h

In summary
- Contact hours: 58 h
- Self-study within semester: 30 h (especially preparation for the interdisciplinary courses and the own lecture)
- Self-study in semester break: 32 h
Total: 120 h

Lecture notes
Documentsations, links and other materials will be provided at the start of the course

Literature
Information on books and other references will be communicated during the course.

Prerequisites / notice
The specialty of this course is that for the first time the animal science disciplines are unified. This is realised with a particular emphasis on interdisciplinary special topics and new forms of teaching. At the same time the essential basics in the central fields are communicated.

Conditions for successful participation: Background on animal science from the Bachelor is desired. In order to attend the Minor in Ruminant Science without any animal science background, a realistic self-assessment concerning the need for additional self-study is recommended (e.g. by choosing an appropriate bachelor course which then may be counted as 'optional courses' in the master). These efforts depend on the extent to which animal science courses have already been attended in the bachelor.

The control of performance will consist of:
- an own short lecture
- a final oral examination with focus on comprehension of the fundamental linkages rather than of specific details

751-7211-00L Ruminal Digestion W 1 credit 1G not available
Does not take place this semester.

Abstract
This course broadens the knowledge in one of the most important aspects of ruminant nutrition: the microbial digestion in the rumen (and in the hindgut). For a comprehensive understanding of the rumen microbial ecosystem, the mechanisms of nutrient fermentation and the synthesis of microbial protein, thorough basics are provided. Apart from lectures, group and laboratory exercises are included.

Objective
The course enables students to understand in detail how ruminal digestion works and how this knowledge can be applied to design optimal feeding diets using highly fibrous forages and a variety of other feeds. The students also are able to show how to modify the most important rumen microbes beneficially by nutritional means.

Content
Structure of the contact hour part of the course (16 h):
2 h Introduction and blackboard exercise
8 h Basic topics in ruminal digestion, lectures and group exercises:
  - Systematics of the microbes involved in microbial digestion
  - Measurement of microbial digestion
  - Interactions of microbes and epithelium of the digestive tract
  - Differences between ruminal and hindgut microbial digestion
  - Microbial nutrient degradation and its modification
  - Efficiency of microbial protein synthesis
  - Manipulation of the ruminal digestion
4 h exercise at AgroVet-Strickhof:
  - Measurements of microbial digestion
  - Laboratory exercise with a rumen fistulated cow and a Rumen Simulation Technique
2 h Final seminar

The non-contact hour part is to comprehend the information given and to prepare either the written report or the oral presentation (cf. "Besonderes")

751-6001-00L Forum: Livestock in the World Food System W 2 credits 1S S. Meese
Number of participants limited to 20.

Abstract
This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.

Objective
In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.
Content
The Forum “Livestock in the World Food System” will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

Part 1
Aspect 1 - Oral presentation: The students form small groups and are lecturers.
Aspect 2 - chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

Part 2.
Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Lecture notes
Introductions to both presentation forms will be given by the lecturer.

Prerequisites / notice
no scriptum

Requirements for allocation of the two credit points:
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)

Feedback on the presentation style of a student

751-6243-00L Breeding and Conservation of Animal Genetic Resources

Abstract
Animal genetic resources refer to the genetic and species diversity of livestock. Only a few production breeds have been further developed through breeding, while local breeds have no longer been able to survive in this competition. Without the support of endangered breeds and the sustainable breeding of productive breeds, many regionally typical breeds are threatened with extinction.

Objective
Learning Objectives: Part 1:
At the end of the course, students are able to assess the importance and problems of small ruminant breeding and husbandry in Switzerland and neighbouring countries. They know the most important breeding objectives and are able to assess them in terms of production and sustainable development in small ruminants and cattle.

Learning objectives part 2:
The second part gives an overview of the distribution, endangerment and conservation of breed diversity of farm animals in Switzerland and internationally. The theory is illustrated with numerous examples and the knowledge is deepened in exercises.

The students:
- have an overview of the national and international distribution of animal genetic resources and are familiar with the database DAD-IS (Domestic Animal Diversity Information System),
- can name the national and international efforts to conserve agricultural livestock breeds,
- know how to describe genetic diversity,
- can point out what is important in the management of small populations,
- can describe different conservation measures, especially in situ and ex situ conservation,
- can describe current national and international conservation programmes for different livestock breeds.

Examination:
Examination Part 1: Graded written examination (1 hour) on the material covered.
Examination Part 2: Graded semester performance completed during the block course.
Parts 1 and 2 contribute equally to the final grade.

Goal Safety and Quality in Agri-Food Chain

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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
</tr>
<tr>
<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>F. Constancias, G. Broggini, S. Bull, A. Greppi, F. Orelli</td>
</tr>
<tr>
<td>752-2307-00L</td>
<td>Nutritional Aspects of Food Composition and Processing</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>B. E. Baumer, J. M. Sych</td>
</tr>
</tbody>
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Lectures
Introduction to both presentation forms will be given by the lecturer.

Requirements for allocation of the two credit points:
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)

Feedback on the presentation style of a student

Introductions to both presentation forms will be given by the lecturer.

Prerequisites / notice
no scriptum

Literature
Actual publications from literature will be provided.

Prerequisites / notice
Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.
Some contents will be provided by registered students who will present as a group an actual publication.

Number
Type
ECTS
Hours
Lecturers
The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.

There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.

The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

### Content

The course provides students with the basic knowledge to understand the connection between the structure of nutritive and non-nutritive bioactive food and feed components and their effects on the nutrient supply and health of humans and livestock as well as on the quality of animal-derived foods.

### Objective

At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

### Content

The course gives an introduction into different classes of bioactive components present in food and feed including fatty acids and secondary plant compounds such as carotenoids, polyphenols, phytoestrogens, glucosinolates, protease inhibitors and monoterpenes.

### Topics include:

- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

### Lecture notes

The teaching slides and other materials will be provided during the course.

### Literature

Information about books and other references will be communicated during the course.

### 751-7310-00L Bioactive Food and Feed Components

**W+ 2 credits 2V K. Giller**

**Abstract**

The course provides students with the basic knowledge to understand the connection between the structure of nutritive and non-nutritive bioactive food and feed components and their effects on the nutrient supply and health of humans and livestock as well as on the quality of animal-derived foods.

**Objective**

At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

**Content**

The course gives an introduction into different classes of bioactive components present in food and feed including fatty acids and secondary plant compounds such as carotenoids, polyphenols, phytoestrogens, glucosinolates, protease inhibitors and monoterpenes.

### Topics include:

- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

### 751-4104-00L Alternative Crops

**W+ 2 credits 2V A. Walter, K. Berger Büter**

**Abstract**

Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

**Objective**

During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

### 751-1551-00L Sustainability Assessment

**Does not take place this semester.**

**Number of participants is limited to 35.**

**Registration for the course is possible until 30.09.2022, Waiting list will be deleted at the same date.**

**Abstract**

The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.

**Objective**

At the end of the course, students:

- know core concepts of sustainable development, main features of social justice in the context of sustainability, a selection of methodologies for the assessment of sustainable development
- have a deepened understanding of the challenges of trade-offs between the different dimensions of sustainable development and their respective impacts on individual and societal decision-making

**Content**

The course is structured as follows:

- overview of rationale, objectives, concepts and origins of sustainable development (approx. 15%)
- overview of the concept of social justice as guiding principle of the social dimension of sustainability (approx. 20%)
- analysis of a selection of concepts and methodologies to assess sustainable development in a variety of contexts (approx. 65%)

**Lecture notes**

Handouts are provided

**Literature**

Selected scientific articles and book-chapters

**Prerequisites / notice**

Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L)

### 751-2105-00L Political Ecology of Food and Agriculture

**W+ 3 credits 2G J. Jacobi**

**Number of participants limited to 25**

A motivational application is required:

- presenting yourself and your studies
- stating what topic in the field of Political Ecology that you are interested in
- suggesting one paper to enrich the literature list for the course

Questions regarding the application to johanna.jacobi@usys.ethz.ch.
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective

- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content

We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Literature

Moodle: https://moodle-app2.let.ethz.ch/mod/assign/view.php?id=756049

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Decision-making</td>
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<td>Self-direction and Self-management</td>
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751-5003-00L Sustainable Agroecosystems II

Abstract

This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

Objective

(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content

The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) in both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management). The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholders in the food system in order to support a sustainable transformation.

Literature


Prerequisites / notice

Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Fostered competencies

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851-0626-01L International Aid and Development

Abstract

The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.

Objective

Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid.

Content

Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

Literature

Articles and book abstracts will be uploaded to a course website.

751-6001-00L Forum: Livestock in the World Food System

Number of participants limited to 20.

Abstract

This forum is a platform for the critical reflection of relevant topics of livestock in the frame of the world food system comprising issues from basic knowledge to acceptance in society. The exchange is operated by scientific writing and presentation.
Objective
In the Forum "Livestock in the World Food System", a topic of significance for livestock agriculture is selected by the students and subsequently dealt with from various angles (from scientific basis to production systems, environmental aspects and to the acceptance by society). The students learn to present a scientific subject in writing and orally to an audience and to defend the presentation in a discussion. Further, feedback is intended to improve the presentation style. Furthermore, the review process of a scientific paper will be demonstrated and applied.

Content
The Forum "Livestock in the World Food System" will take place in blocks of 2 hours each. Once the general topic has been selected, it comprises two parts:

Part 1
Aspect 1 - Oral presentation: The students form small groups and are lecturers. Aspect 2 - chair person: There are moderators which are chosen from outside of the presenting groups and they will lead the discussion and the remaining students and the lecturer are the audience and ask questions.
Aspect 3 - feedback: At the beginning, students form teams of 2, which are not in the same group, to give each other feedback on their presentation style.

Part 2.
Aspect 1 - Scientific writing: Preparation of a critical review of a chosen publication and individual exchange with the lecturer.
Aspect 2 - Defense: There will be a discussion in small groups on several dates to discuss the chosen publication in detail and the observations during the process.

Introductions to both presentation forms will be given by the lecturer. Lecture notes
no scriptum

Prerequisites / notice
Requirements for allocation of the two credit points:
- oral talk with sufficient handout
- delivery of the scientific writing in sufficient quality
- active participation during all presentations (in case of absence there will be additional tasks)
- Feedback on the presentation style of a student

751-5201-10L Tropical Cropping Systems, Soils and Livelihoods (with Excursion) W+ 5 credits 10G J. Six, K. Benabderrazik

IMPORTANT: Students who enroll for this course are strongly recommended to verify with lecturers from other courses whether their absence of two weeks may affect their performance in the respective courses.

Abstract
This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in Kenya, which is co-organized with Eldoret University (Kenya) and KU Leuven (Belgium).

Objective
(1) Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
(2) Interdisciplinary analysis of agricultural production systems
(3) Knowledge on methods to assess agroecological performance of a tropical agroecosystems
(4) Hands-on training on the use of field methods, diagnostic tools and survey methods.
(5) Gain practical knowledge on how to assess to climate resilience and farming systems.
(6) Collaboration in international students and stakeholders

Content
This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, climate mitigation, agroecology, resilience to soil physics or agricultural economics. Students will engage in readings, discussions and exchanges on the specificities of tropical agriculture.
On, students gain practical knowledge on field - An integral part of the course is the two-week field project in a Tropical region, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

On the second module, students gain practical knowledge on field - An integral part of the course is the two-week field project in Kenya, conducting various assessments related to Food and Energy Security.

Prerequisites / notice
We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 23rd 2022, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.

Fostered competencies

- Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management
- Social Competencies
- Communication
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Personal Competencies
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Electives Courses
Elective courses can be chosen from the entire course programme of the ETH Zurich as well as from the course programme of the University of Zurich.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>W+</td>
<td>Environmental Systems Data Science: Data</td>
<td>2</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne,</td>
<td></td>
</tr>
</tbody>
</table>
**Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.**

Number of participants is limited to 80.

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

**Target groups**
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

**Abstract**

Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

**Objective**

The students are able to:

- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

**Content**

- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

**Prerequisites / notice**

- 252-0840-02L Anwendungsnahes Programmieren mit Python
- 401-0624-00L Mathematik IV: Statistik
- 401-6215-00L Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften

**751-5510-00L Introduction to Agricultural Robotics**

- **W+** 3 credits 2G S. Mintchev

**Number of participants limited to 30.**

**Abstract**

Autonomous robots are quickly becoming a key player in the transition to precision agriculture. In this course, students will learn theoretical and practical aspects of robotics. Lectures will introduce how robots operate and analyse their application to precision agriculture. In hands-on laboratories, students will apply concepts learned in class on educational robots to simulate a weeding task.

**Objective**

After the course, students will be able to critically examine and select appropriate robotic solutions for agricultural applications. The learning objectives of the course are: (i) illustrate the principle of operation of the main components of a robotic system, (ii) analyse how the different robotic components are integrated and contribute to the functioning of a robotic system, and (iii) solve problems in the field of agriculture using robotic principles.

**Content**

Robots are becoming a key technology in the transition to smart farming and in supporting the agricultural needs of the 21st century. For example, robots enable site-specific fertilization, automated weeding, or livestock herding.

The course gives an overview of robotic systems, beginning with their fundamental components (e.g., sensors, actuators, locomotion strategies) and gradually scaling up to the system level, illustrating the concepts of perception, robot control, obstacle avoidance and navigation. Exercises performed with an educational robot (Thymio) will complement the theoretical lectures providing a hands-on practical experience of using these machines.

During the course, students will gradually apply the theoretical and practical knowledge they are learning. To this end, students will work in teams to develop a robotic solution for an agricultural task of their choice. Students will learn to translate the task into meaningful requirements for a robotic system and critically select the most appropriate components to achieve the required robotic functions. Students will periodically present and discuss the development of this “robot design” exercise during presentations and in a journal report.

**Lecture notes**

Copies of the slides and exercises will be provided on the course Moodle page.

**Literature**


**Prerequisites / notice**

No mandatory prerequisites, but it is preferable that students have a basic knowledge of computer programming.

Class size limitation to 30 students.
Agroecology (HS)

In Spring Semester a related course (Agroecology FS) will be offered. The course Agroecology (HS) is not a prerequisite, the courses can be taken independent of each other.

Abstract
Agroecology is a discipline, an agricultural practice, and a political-social movement. Students will attend five public lectures in which experts from different fields reflect on agroecology and its principles. Based on these inputs, students will reflect and discuss about the role of agroecology to support sustainable agriculture and food systems.

Objective
Students know the thirteen principles of the High-Level Panel of Experts (HLPE) of the Committee on World Food Security as well as the ten elements of agroecology suggested by FAO and can critically reflect on the important properties as well as benefits and trade-offs of agroecological systems and approaches.

Content
The course is designed as a combination of a series of five public lectures/webinars on “Agroecology and the Transformation to Sustainable Food Systems” delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended to fuel the students’ sessions in the second part of each course. In the student sessions the student groups first get to know one of the 13 principles of the HLPE. During the course, students discuss the potential and limitations of agroecology and learn about scientific contributions to agroecology. Students form an opinion on the role of agroecology as well as to reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

Fostered competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- Personal Competencies
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

Lecture notes
Handouts will be available on the webpage of the course.

Literature

Prerequisites / notice
This course is based on fundamental knowledge about plant ecophysiology, soil science, biogeochemistry, crop and forage science, and ecology in general. The course will be taught in English. The course is offered in spring and fall (different agroecology principles will be addressed). Thus, both courses are not sequential, but can be taken in any order.

Master’s Thesis

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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>Master’s Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Lecturers</td>
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</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
The Master thesis is an independent scientific work. Normally the subject is selected among the topics of the core subject. It is written under the guidance of a agricultural sciende professor.

Objective
The independent writing of a scientific paper/thesis

Data: 01.11.2022 12:41
Autumn Semester 2022
### Agricultural Sciences Master - Key for Type

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<td>G</td>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>Courses outside the curriculum</td>
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<td>W</td>
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### Key for Hours

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<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
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<td>R</td>
<td>revision course / private study</td>
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### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
**Applied Geophysics Master**

*Courses at ETH Zurich only take place in Spring Semester.*

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<thead>
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<th>Applied Geophysics Master - Key for Type</th>
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**Key for Hours**

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**ECTS**

European Credit Transfer and Accumulation System

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Architecture Bachelor

First Year Examinations

Examination Block 1

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<td>052-0603-00L</td>
<td>Structural Design I</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>P. Block, J. Schwartz</td>
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</table>

Abstract
The courses Structural Design I and II explain the fundamentals of how structures function. These courses put great emphasis on studying the relationship between the form of a structure and the internal forces within it by means of graphic statics.

Objective
At the end of the courses Structural Design I and II, students will be able to:

1. visualize the internal forces within structural elements.
2. understand the relationship between the form of a structure and the internal forces within it.
3. modify the design of a structure in order to improve it.
4. identify the most important structural typologies.
5. use graphic statics for the form-finding and analysis of structures.
6. carry out basic dimensioning of structural elements.
7. respond to structural problems in a creative manner.

Content
Structural Design I:
- Fundamentals of static equilibrium
- Introduction to graphic statics
- Basic dimensioning of structural elements
- Cables and stiffening schemes of cables
- Arches and stiffening schemes of arches
- Arch-cables structures

Structural Design II:
- Trusses
- Beams
- Frames
- Plates
- Buckling of compression elements

Lecture notes
on eQuilibrium
"Skript Tragwerksentwurf I/II"
http://www.block.arch.ethz.ch/eq/course/4?lang=en

A printed version can be bought at the chair of Structural Design Prof. Schwartz for sFr. 55.-.

Literature
"The art of structures, Introduction to the functioning of structures in architecture"

"Faustformel Tragwerksentwurf" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2013, ISBN: 978-3-421-03904-0)


052-0703-00L Sociology I

Abstract
Sociology I investigates the relation between social developments and the production of the built environment from a macro-sociological point of view. It examines central aspects of social change, historical and contemporary forms of urbanization, and typical examples of models of urbanization.

Objective
This series of lectures should enable students to comprehend architecture in its social context.

Content
Sociology I deals with the macro-sociological point of view, and investigates the relation between social developments and the production of the built environment. In the first part central aspects of social change are examined, in particular the transition from Fordism to Neoliberalism and the interlinked processes of globalization and regionalization. The second part deals with historical and current forms of urbanization. Among other aspects, it focuses on the changed significance of the urban-rural contradiction, the processes of suburbanization, periurbanization, and planetary urbanization; the formation of global cities and metropolitan regions; the development of new urban configurations in centres (gentrification) and in urban peripheries (edge city, exopolis, new urban intensity). In the third part these general processes are illustrated by typical models of urbanization: Manchester, Chicago, Los Angeles, Paris and Zürich.

Literature
A detailed collection of original texts will be distributed.

052-0901-00L Building History I

Abstract
History of building from classical antiquity to modernity: building types, constructions, forms, with particular reference to functional issues such as flexibility of use, statics, durability. This is not a mere history lecture, but an important part of the basic introduction into construction.

Objective
Participants know the fundamentals of building history, including landmark monuments of each era, key historic constructions and forms. They are able to “read” a historic building and to relate it to building history. They are aware of the variety of historic building constructions.
**Content**
Building history I covers the period from classical Greek antiquity to Gothic architecture. The principal topics include construction issues such as Greek megalithic building, Roman mortar-and-rubble construction, and Gothic rationalism of vaulted architecture.

Within the Vitruvian and Albertian triad of firmitas, utilitas and venustas, we focus on the first two topics, whereas the last topic (deciphering the "meaning" of architecture) stands at the heart of the "architectural history" lectures. The present lecture contributes essentially to deepening knowledge about historic constructions, an indispensable precondition for building within existing fabric.

**Lecture notes**
Please keep a tight record of manuscript notes yourself. Lecture notes to some topics will be provided. pdf of lecture slides will be on line before each lecture.

**Literature**
Will be announced during the lectures.

**Examination Block 2**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>052-0803-00L</td>
<td>History and Theory of Architecture I</td>
<td>O</td>
<td>2</td>
<td>2+2U</td>
<td>M. Delbeke, T. Avermaete, L. Stalder, P. Ursprung</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction and overview of the history and theory of architecture from the Renaissance to the nineteenth century. The course covers the chronology and key works, protagonists and discourses of early modern European architecture.

**Objective**
1. Acquiring basic knowledge of the history and theory of architecture during the early modern period, of its key protagonists and discourses and of the methods and instruments of architectural research.
2. Identifying the main architectural issues and debates of the period and recognising the places and architectural works covered in the course.
3. Acquiring the tools to develop a historically informed reading of the built environment, recognising debates, styles, ideas and problems which drive and inform architectural production.
4. Developing the tools to draw on historical, theoretical and critical research to the benefit to one's own architectural culture.

**Content**
The course 'History and Theory of Architecture I-II' offers a chronological and thematic survey of early modern architecture and architectural theory produced in Europe from the 15th up to 19th century. The course is based on thematic lectures, analysing key European architectural works, texts and iconography. Themes will include the origin of the Vitruvian tradition in architectural theory and practice and its dissemination in Italy during the 15th and 16th centuries; the mediatisation of architectural principles through the development of book production during the 16th century; the development of divergent theories of architectural composition and design in Italy and France between the 16th and 17th centuries; the formation and international spread of religious symbolism through architecture; analyses of original design practices, such as in the case of Michelangelo; a study of building types, such as the palazzo and the villa, and their codification by architects like Andrea Palladio; debates over questions of beauty and ornament, especially in the 17th and 18th centuries; questions of patronage and the relationship between architecture and political and religious powers (e.g. the French Monarchy and the Roman Papacy); the relation between buildings and their urban setting in the development of European capitals like Rome, Paris and Berlin; historicism and attitudes towards the past in architectural styles.

In addition to the main lectures, the course ‘History and Theory of Architecture I-II’ will also include a series of seminars, called ‘Small Narratives’. These seminars are meant to widen the scope of the programme by exploring case studies, such as buildings and ruins in Zurich, which relate and contribute to the content of the course. While content of the ‘Small Narratives' seminars is not part of the exam, students are invited to make use of it for their study, and attendance is compulsory.

The course ‘Fundamentals for the History and Theory of Architecture I-II’ aims to explore and develop basic methods and strategies to research the history of art and architecture. It consists of four parts, each developed under one of the four Chairs of the gta, and each dealing with a particular area of study in the field of architecture and art history. The course will consist of four different exercises and tasks, carried out under the supervision of each of the four Chairs throughout the year:
1. Architecture and books (M. Delbeke)
2. Architecture and media (L. Stalder)
3. Architecture and art (P. Ursprung)
4. Urbanism and the Commons (T. Avermaete)

**Literature**
Course scripts, PowerPoints and lecture recordings for ‘History and Theory of Architecture I-II’ will be available to download from the course page at the beginning of the semester. Printed copies of the course scripts will also be available for purchase.

**Prerequisites / notice**
For the course ‘History and Theory of Architecture I-II’ students rely on assisted self-study to acquire basic knowledge of the history of architecture in Europe.
Abstract
Building Materials - Introduction to the most common building materials

Raw materials + Production
Properties + Application
Ecological footprint + Recycling

Objective
The lecture develops an understanding of different building materials and its application for construction under the aspects of material properties and ecological aspects.

Content
The lecture introduces the most common building materials concrete, steel, masonry and timber, but also clay, glass and polymers in a historical context. The fabrication processes are described and the most important properties regarding construction explained. A special focus is on the ecological aspects such as availability of raw materials, effort for production, emission of hazardous substances, disposal and recycling.

Lecture notes
Lecture slides as pdf

052-0701-00L Urban Design I

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<tr>
<th>O</th>
<th>2 credits</th>
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<th>M. Wagner</th>
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<tr>
<td>Urban Design I</td>
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Abstract
The means and potentials in the field of urban planning and design are pointed out from different perspectives in order to shape the city in the sense of a future-proof and humane environment. To this end, the basic principles are explained and concrete methods of urban design are presented.

Objective
The goal is to provide students with a broad systemic basic knowledge, that enables them to synthesize and evaluate complex urban design and planning problems.

Content
The lecture series imparts basic knowledge in urban planning and design. Pressing questions and main topics of contemporary urban design practice and theory will be addressed. The focus is on illustrating the richness of relationships as well as the potential of the discipline and its handling in everyday urban planning and design practice.

Lecture notes
There is no script to the lecture series. The lectures are recorded on video and made available online on http://www.video.ethz.ch/lectures.html a few days after each lecture.

Literature
At the end of the year course a reader with secondary literature will be made available for download.

Prerequisites / notice
Further Informations:
https://www.staedtebau.arch.ethz.ch

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Techniques and Technologies</th>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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052-0605-00L Computational Design I

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<tr>
<td>Title of this course before HS22: &quot;Mathematical Thinking and Programming I&quot;</td>
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Abstract
This course introduces computational design and teaches how design can be modeled and materialized using digital technology. Participants learn to use the computer strategically, thoughtfully, and sensitively within the design process. With the “digital literacy” acquired in this course, they develop an understanding of the potential of a digital building culture.

Objective
To systematically harvest the potential of the computer in their work processes, architects need an insight into the fundamental principles of information technology. In this course, students learn the concepts, methods, and instruments of computational design. By the end of the two semesters, students will have mastered the basics of 3D modeling techniques, parametric design, programming code for Computer-aided-design (CAD), and digital prototyping. The acquired knowledge qualifies students to use the computer as a unique instrument to model their designs. Participants also learn to apply CAD and programming code creatively and productively in planning, design, and construction.

Specifically, the learning goals are:
- Critical understanding of the possibilities of information technology in design
- Acquiring an overview of the mechanisms and types of CAD systems and digital building models
- Gaining knowledge of the basic principles of computational geometry
- Applying visualization techniques and creatively using various digital media
- Learning concepts and application of parametric design.
- Being able to integrate computer-aided analysis and optimization methods in design-process
- Understanding the principles of digital process chains from design to production
- Strategically using visual programming code
- Reading, understanding, and adapting programming code within CAD software.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 75 of 2416
Architecture is no longer conceivable without information technology. The planning, construction, operation, and ultimately the nature of buildings are increasingly influenced by digital technology. The digital is omnipresent both in the work of architects and in our built environment itself.

The courses Computational Design 1 and 2 offer an introduction to the character, challenges, and possibilities of digital technology in architectural design. The lectures will discuss the topics of digital building models and data, computational geometry, digital fabrication, machine intelligence, and mixed reality.

In this course, students will practice digital modeling processes and related techniques. The spectrum of exercises includes manual modeling, visual programming, and programming code within CAD software. Students learn to read, understand and adapt this code. In addition, the courses will provide insights into the nature and handling of different digital media formats, from real-time rendering to mixed reality.

Topics discussed within the lectures:
- CAD - background, and developments
- On the nature of digital models and data
- Architectural geometry
- Computational geometry
- Parametric and generative creation of models
- Computer-aided analysis and optimization of models
- Artificial intelligence and architectural models
- Materialization of digital models
- Mixed reality

Course Structure
The course consists of theoretical lectures, practical tutorials introducing technical concepts, and exercises supported by tutors. Participants can find updated and detailed information on Moodle, which is the learning platform for the course.

Subjects with Semester Grade

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>052-0501-00L</td>
<td>Design and Construction I</td>
<td>O</td>
<td>8</td>
<td>4V+10G+2U</td>
<td>A. Deplazes, D. Mettler, D. Studer</td>
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</table>

**Abstract**
Designing and constructing will be understood to be a complementarily complementary offer. The content and methodical foundations of design and construction are taught and deepened through lectures and exercises.

**Objective**
Understanding and dominating the methodology of designing and constructing.

**Content**
Lectures and exercises to achieve the methodology and ability of designing and constructing.

**Lecture notes**

**Literature**
Book recommendation Entwurf und Konstruktion I/II:
Constructing Architecture
Ed. Andrea Deplazes
German, English, French, Spanish
ISBN 978-3-0356-1669-9

Further Literature will be published in the lectures.

**Prerequisites / notice**
100% of interest and engagement!
Participation in the seminar week of the Deplazes chair ("Hybrid Modeling") from 24th to 28th October 2022 is compulsory!

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<tr>
<th>Number</th>
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<td>052-0503-00L</td>
<td>Architecture and Arts I</td>
<td>O</td>
<td>8</td>
<td>2V+6G+1U</td>
<td>K. Sander</td>
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</table>

**Abstract**
Participation in the seminar week of the chair Deplazes (topic "Hybrid Modeling") is mandatory!
Project grading at semester end is based on the list of enrolments on 1.11.22 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

**Content**
Attendance in the lecture „Thinking and Speaking about Art”. Participation in three praxis-modules. Elaboration of three according artistic excercises in the framework of the group mentorates. (Emphasis of grading for the final semester grade: 3 x 1/3 artistic excercise.)

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<tr>
<td>052-0607-00L</td>
<td>Structural Design III</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>J. Schwartz, P. Block</td>
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</table>

The course Structural Design III complements the courses Structural Design I and II, which show the fundamentals of how structures function. The course explores the relationship between architecture and structure by analyzing buildings built from the main structural materials.

Data: 01.11.2022 12:41   Autumn Semester 2022   Page 76 of 2416
Objective

At the conclusion of Structural Design III, students will be able to:

1. understand the structural behaviour of a building.
2. design efficient and expressive structural systems.
3. extend the application of graphic statics from 2D to 3D.
4. assess the structural and architectural potentials of the most important building materials.
5. establish a relationship between material aspects, form and forces.
6. understand how construction details work from a structural perspective.
7. carry out basic dimensioning of structural elements.

Content

After a brief review of the key aspects taught in Structural Design I and II, the course Structural Design III will examine the interplay of architectural concepts and structural systems by analyzing buildings of exemplary quality. Structures built out of steel, reinforced concrete, timber and masonry are studied. During the exercise sessions, three-dimensional structures will be analyzed using graphic statics taking into account the relationship between form, forces and material aspects.

Lecture notes

eQUILIBRIUM

https://block.arch.ethz.ch/eq/course/81

Literature

"The art of structures. Introduction to the functioning of structures in architecture"

"Faustformel Tragwerksentwurf" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2013, ISBN: 978-3-421-03904-0)


Prerequisites / notice

To take part in this course, it is recommended to first complete the courses Structural Design I and II or to have knowledge of graphic statics.

Fostered competencies

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<th>Subject-specific Competencies</th>
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<tbody>
<tr>
<td>052-0805-00L</td>
<td>History and Theory of Architecture III</td>
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</table>

Abstract

This two-semester course is an introduction to the history of architecture from the Second Industrial Revolution in the 1850s to the Oil Crisis in the 1970s in Europe. Students will be able to identify the "things"—technical objects and ensembles—that transformed architecture, and to relate them to the technical, scientific, and cultural concerns that introduced them as key features of modernity.

Objective

To introduce students to the history and theory of architecture, the course has three objectives.

First, students will be able to identify the "things" that transformed architecture in modernity, and the crucial events, buildings, theories, and actors that characterize their history. Second, students will be able to describe how these "things" operated at different scales, focusing less on the formal level, and naming instead the different forms of expertise that constituted them historically, as well as the processes within which they were embedded. Third, students will be able to reflect on a series of apparatuses, devices, and building parts that are in fact micro-architectures which have often been neglected, despite their pivotal role in shaping the daily lives of modern societies.

Content

The course proposes a new approach to the study of the history and theory of architecture in Europe during modernity. It focuses less on single architects or their buildings, and more on those "things" that have brought profound transformations in the built environment and daily life over the last 200 years, such as the revolving door, the clock, and the curtain. The notion of "thing" includes both the concrete building parts and the concerns associated with them, such as material performance, social synchronization, and individual expression. To understand buildings as assemblages of "things," therefore, does not mean to diminish their significance, but on the contrary to add reality to them, to understand them in terms of the complex, historically situated, and diverse concerns within which they were designed.

Each lecture introduces one "thing" through a genealogy that shaped it, from patents and scientific discoveries and technological advancement, to cinema, the visual arts, and literature. A set of renowned projects as well as lesser-known buildings from all around Europe offers a variety of case studies to describe these "things," to understand how they operated in relation with one another, and to identify the theories and tactics that architects mobilized to make sense of them.

Lecture notes

http://www.stalder.arch.ethz.ch/courses

Fostered competencies

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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<th>F. Gramazio, M. Kohler, J. Medina Ibañez</th>
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<tbody>
<tr>
<td>052-0635-00L</td>
<td>Computational Design III</td>
<td>2</td>
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</table>

Title of this course before HS22: "Mathematical Thinking"
In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their contexts, thus offering a theoretical framework for students' future design work.

The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

The course consists of lectures and exercises. The lectures convey an insight into strategies for the implementation of algorithmic techniques in architectural design by presenting and discussing the research and the build work of the professorship. This pragmatic view on the computational design process helps demystifying algorithmic techniques and developing a critical understanding for their potentials in the architectural praxis. Programming is an extension of traditional design tools. While this powerful cultural technique allows us to handle complexity in a previously unknown way, the question of its meaning, relevance and potential needs to be negotiated on a context specific base for every single project. In order to be able to do this, we shall develop a conceptual understanding for the methods as well as familiarity with the practice of programming. While the works discussed in the lectures sharpen the conceptual understanding, the tutored exercises will train the programming practice. In these sessions, we will implement simplified yet powerful versions of the discussed projects by using Rhinoceros 3D as a modeler and Grasshopper as a visual programming interface, both environments that have been introduced in the previous semesters. Up-to-date and detailed information on the lectures and exercises is announced on MOODLE, which will serve as the teaching platform for this course.

The specific learning goals are:
- To develop a critical awareness for the potentials of algorithmic design methods.
- Learn to deploy parametric design strategies.
- Become familiar with the practice of visual programming.
- Understand the concepts and potentials of digital fabrication.

### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>052-0801-00L</td>
<td>Global History of Urban Design I</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>T. Avermaete</td>
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</table>

This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.

In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01. The History and Theory of the City as Project
02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03: The Idea of the Polis: Rome, Greece and Beyond
04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06: Baroque and Enlightenment: Baroque, Defense and Colonization
07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
09: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
010: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
011: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

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<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>H. Klumpner, M. Fessel</td>
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</table>

Students are introduced to a narrative of 'Urban Stories' through a series of three tools driven by social, governance, and environmental transformations in today's urbanization processes. Each lecture explores one city's spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.
How can students of architecture become active agents of change? What does it take to go beyond a building’s scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, which in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasons, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

The learning material, available via https://moodle-ap2.let.ethz.ch/ is comprised of:
- Toolbox ‘Reader’ with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

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- Toolbox ‘Reader’ with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings

Reading material will be provided throughout the semester.

Autumn Semester 2022

052-0807-00L History and Theory of Architecture V
Type: O
ECTS: 2
Hours: 2V
Lecturers: P. Ursprung

Objective: History of Art and Architecture since the 1970s
The course target is to let the students gain a overview of a line of formative occurrences, works of art, buildings and theories from the Landscape Architecture I

052-0651-00L Building Process I
Type: O
ECTS: 2
Hours: 2G
Lecturers: S. Menz

Objective: Process thinking and a look at neighbouring countries complement the series.

052-0705-00L Landscape Architecture I
Type: O
ECTS: 2
Hours: 2V
Lecturers: C. Girot
The slides of the lecture serve as lecture notes and are available as download.

The lecture series does not provide instructions or recipes on general constructive topics. The description of distinctive, spatial experiences focuses on the spatial and cultural relationship between the garden, the city and the landscape, as well as the changing perceptions of nature and its representation.

Lecture notes
Handouts and a reading list will be provided.

Literature
A reading list will be provided for the exams.

Prerequisites / notice
General Information for the final exam: Bachelor students: The content of the lectures as well as texts and exam-relevant literature provided by the Chair make up the basis for preparing for the exam. The lecture series is conceived as a yearlong course. Since the written session examination will test knowledge from both semesters, it is necessary to fully attend the lectures of both courses "Landscape Architecture I" and "Landscape Architecture II". The themes of the examination will be announced at the end of the semester. The Chair will provide literature and texts available for download as pdfs. These allow a more in-depth understanding of the lecture material.

Exchange students or students from other departments: Students, who are attending only one semester, may pass the oral end-of-semester examination. Test-relevant literature will also be made available for download for this purpose. The students are requested to get in touch by email with the Chair.

<table>
<thead>
<tr>
<th>Code</th>
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<th>Credits</th>
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<tbody>
<tr>
<td>052-0609-00L</td>
<td>Energy and Climate Design I</td>
<td>2</td>
<td>This course can only be taken if Energy and Climate Design II is taken in the following semester, as the group work is connected and extends throughout the year.</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td>This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.</td>
</tr>
<tr>
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<td>Objective</td>
<td></td>
<td>At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (<a href="https://moodle-app2.let.ethz.ch/course/view.php?id=11917">https://moodle-app2.let.ethz.ch/course/view.php?id=11917</a>). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.</td>
</tr>
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<td></td>
<td>Content</td>
<td></td>
<td>Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course: 1. Local potentials 2. Demand 3. Supply</td>
</tr>
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<td>052-0507-00L</td>
<td>Architectural Technology V</td>
<td>2</td>
<td>This course is the prerequisite for making an architectural, spatial idea tangible in the first place. In this lecture series, it is understood as a component of a holistic, coherent architecture and is derived from its architectural, spatial context on the basis of a broad selection of buildings.</td>
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<td>Abstract</td>
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<td>Construction is the prerequisite for making an architectural, spatial idea tangible in the first place. In this lecture series, it is understood as a component of a holistic, coherent architecture and is derived from its architectural, spatial context on the basis of a broad selection of buildings.</td>
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<td>The lecture series does not provide instructions or recipes on general constructive topics. The description of distinctive, spatial experiences and the constructive measures used to achieve them, is rather intended to sharpen the students' awareness, for their own design work and to show countless possibilities of how an architectural, spatial idea can be understood and further developed through its material, its construction method and its supporting structure.</td>
</tr>
<tr>
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<td>Content</td>
<td></td>
<td>The buildings, which are described and explained in the lectures, differ fundamentally from each other in their time of origin, their urban context, as well as their geographical location and could hardly be more different in their scale and their use. These buildings are not a typical expression of their time and location, instead they are an expression of an individual creation and likewise use the constructive possibilities of their time and their environment in a distinctive way. Accordingly, each lecture is dedicated to a different architect. In addition, isolated current examples from professional practice will be shown. These lectures on new buildings, some of them unfinished, are given by an architect directly involved on site, in English, and partly online.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td>The script is a comprehensive collection of material that allows students to form their own ideas about the case studies shown, independent of the lecture. Most of the photographs were taken on study trips and show the buildings under discussion with unpublished material. The extensive collection of photographs is supplemented with drawings, plans, site photographs, and historical photographs from books and archives. The script will be made available in digital form at the end of the semester to students enrolled in the lecture series.</td>
</tr>
<tr>
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<td>Literature</td>
<td></td>
<td>The script will be made available in digital form at the end of the semester to students enrolled in the lecture series.</td>
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</tbody>
</table>
Structure and topics of the lecture series:
26.09.22: Einleitung;
03.10.22: John Lautner;
10.10.22: Kazuo Shinohara;
17.10.22: Francesco Borromini;
31.10.22: Louis Kahn;
07.11.22: André Block;
14.11.22: 4 Parkings Bahrain;
21.11.22: Pavilion Expo 2020 Dubai;

The examinations test knowledge of the buildings presented in the course of two semesters. The focus of the exam, as well as the lecture, is the understanding of the indissoluble connection between the spatial experience or conception of a building and its construction, its load-bearing structure, its construction process and its materials.

The lectures are not a mandatory prerequisite to pass the exam, but a clear introduction to the exam material, as well as a facilitation to understand and deepen the exam material. The structure of the exam material changes from one semester to another and from one year to the next. Exams can therefore only cover the lectures of a whole year.

Mobility students or students from other departments who only want to take the exam on the material from the last semester (Construction V or VI) are asked to contact the chair in advance.

► Architectural Design

►► Architectural Design (3. Semester)

<table>
<thead>
<tr>
<th>Number</th>
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Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). Students who do not wish to change the design class don't have to participate in the internal enrolment.

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
Housing is our studio's topic. We begin with a three-day excursion to Turin. Based on selected examples, we study Turin's urban architecture. Collectively we develop both a typology and an architectural vocabulary through inspired drawings. In the second half of the semester, we design a piece of furniture. This architectural object is the ideal house.

Objective

Content
This year our studio deals with housing. We start the semester with a three-day excursion to Turino, the northern Italian city on the Po River at the foot of the Alps, capital of the Savoy dynasty and briefly of Italy, with its grid structure and building blocks, early workers' villages and industrial settlements in the suburbs. Based on selected examples of both anonymous structures and famous buildings, we study the urban architecture of Torino. We start our common journey of discovery with an analysis - open and experimental, but also systematic and critical. Together we discover, examine and document each house, discuss and develop criteria and categories, in order to eventually compare and order them. The result of this process is our own Torino typology. Through drawings, not just mere representations, but inspired and personal depictions of these architectures we develop together a collective, common repertoire of timeless architecture. Playfully and at the same time systematically, we work on a shared vocabulary of architecture.

Finding one's own architectural language within the vast vocabulary of architecture is the most important but also most difficult task for an architect - and therefore the task of the second half of the semester. Each group creates an independent design. Whether out of a discovered principle or a very personal fascination, each group develops an independent and experimental design: a piece of furniture, a domestic object. Bare of the necessity to fulfill a certain function, a small piece of furniture and a large house are quite alike, as objects both are shaped by formal coherence and constructive, material decisions. The medium of the semester's second half is the large scale model. Each of these architectural objects is an ideal house.

Literature
Book recommendation BUK I - IV: "Construction": A reference work on contemporary construction German or English
360 pages, 171 images, 20 color images, texts
ISBN 978-3-0356-2225-6
Online reference source: https://www.hochparterre-buecher.ch/ Konstruktions.html

Prerequisites / notice
Group work only.

Introduction: 20 September 2022, 10.00 am, HIL F41
Intermediate crits: to be announced
Final crits 20.12/21.12.2022
Extra costs: Approx. CHF 100.-- per student.
Abstract
A course on house and housing design in Switzerland. Analysis of existing houses, including their users and locations serves as a basis for the design of a housing complex. The course teaches basic principles of housing design as well as diving into topics such as the relation between public and private, common and shared spaces and urban ecology.

Objective
Typology and Research (4 weeks)
- able to understand different housing typologies within their historical context. (2)
- able to understand the principles of housing design, including topics such as Typology, Program, Usage, Privacy, Commonality, Material and Climate. (2)
- able to independently gather information on a self-chosen topic (3)
- able to analyze a case study house based on an individually formed question or individual interest. (4)
- able to represent their analysis in a drawing and a short text. (3)

Structure and Space (4 weeks)
- able to design a small-scale housing complex according to the above-mentioned principles. (3)
- able to design spaces for privacy and for community. (3)
- able to adapt a housing design to the needs of specific inhabitants with partially special needs, such as families and elderly. (3)
- able to apply the principles of structural design to their housing design. (3)
- able to critically evaluate a design and improve it. (5+6)
- able to represent a design through drawings, sections and elevations as well as with physical models (3)

Improving Design + Details and Construction (5 weeks)
Each individual student
- able to detail a small-scale housing complex. (3)
- able to understand the principles of construction. (2)
- is able to gather examples and evaluate them in accordance with their design (5)
- is able to evaluate and choose materials and construction in accordance with their design idea (5).
- is able draw a section of their design in scale 1:50 with all necessary details. (3)

Cognitive Scale
(1) Remember
(2) Understand
(3) Apply
(4) Analyze
(5) Evaluate
(6) Create
https://ethz.ch/content/dam/ethz/main/eth-zurich/education/lehrentwicklung/files_DE/Vorlage_LernzieleFormulierenDe.pdf

Grading Criteria:
The submissions will be graded before each review. Each submission is graded according to the following criteria:
- Completeness and punctuality of submission
- Research method, the ability to find and analyze information
- Implementation of the concept of Architectural Behaviorology within the design
- Choice of Typology, Design and Expression of the project, in connection with the concept of Architectural Behaviorology
- Structural design, construction details and choice of materials in accordance with the design idea and the method of Architectural Behaviorology
- Visualization, the ability to communicate a design effectively with compelling drawings, models and text.

The final grade consists of the following partial grades:
- Mid review 1 submission (individual work): 30%
- Mid Review 2 submission (individual work): 30%
- Final Review submission (individual work): 40%
Architectural Behaviorology and Actor Network Theory are our two guiding principles to not only design architecture but also understand our current existing environment.

By understanding a building, a house not as an isolated object but as a node in a vast and far reaching network, or several networks, we grow conscious of the impact, which our design has, not only on the specific plot, but on the neighbors, the city, the environment, the society. Vice-versa, analyzing and understanding the relationships, which have shaped existing buildings, helps us to better understand how and why the design of those buildings came to be.

While identifying the relationship between actors within the network, we simultaneously observe the behavior of each actor as a result of their relationship. The behavior can be static or dynamic, actors can be human, non-human, animate or inanimate. How does a building behave towards its environment? What behavior do inhabitants engage in within and around a building? How do we have to design to take Behaviors of certain materials into account?

House and Housing is the base of our living environment and a diverse field in architecture. House behaviorology will set the challenge to find sustainable living condition in the city, by understanding historical examples and their geography, density, economic standing, and time period.

At first, to find the character and essence of today’s house and housing design in Geneva, we will start with analyzing existing single-family houses in and around the city. We will research and map how these basic units of housing relate to the users, to each other and to their surroundings. What kind of purposes they fulfilled and what kind of activities and behaviors do these houses enable?

Second, we will try to improve on the design by changing the single-family house into housing complexes, responding to the need of greater density, but still retaining the qualities of the original houses. Where do we find synergies, when combining houses? What kind of common spaces arise and how can we make use of them to make better neighborhoods?

Simultaneously we will have a close look on designing for inclusivity. How do we design for partially special needs groups, such as the elderly or children? How can we all live together in a house and in the urban ecology?

The course is structured as follow:

**Typology and Research (4 weeks)**
- Analyzing an existing single-family house in Geneva according to the principles of Architectural Behaviorology und the historical context of the said house.
- Defining a special interest for an element or relationship between elements of the chosen house and defining a question as a tool to better understand this field of interest.
- Representing the house and the research in a large-scale drawing and a short text.

**Structure and Space (4 weeks)**
- Designing a housing complex with a given program on the basis of the analysis of the case study single-family house.
- Evaluating and adapting the design constantly.

**Improving Design + Details and Construction (5 weeks)**
- Applying the principles of structural design to the design project.
- Constantly improving the design and sharpening the design idea.
- Detailing one section in the scale of 1:50 by applying the learned principles of construction and structural design as well as adding details in accordance with the principles of Architectural Behaviorology.
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Each student will receive a printed reader, containing the basic information about the course, such as schedule, syllabus and other important information, as well as examples and references for the design task, and readings to support the theoretical framework of the course.

**Lecture notes**
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**Literature**
- Atelier Bow-Wow, Behaviorology, Rizzoli International Publications, New York, 2010
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- Atelier Bow-Wow, Behaviorology, Rizzoli International Publications, New York, 2010

**Prerequisites / notice**
To attend this course, students have to enroll through the “Enrolment in the Design Studios of D-Arch”-page: (www.einschreibung.arch.ethz.ch/).

The design studio is structured as a year-long course.

The submissions during the autumn semester will be individual work.

**052-0545-22L Architectural Design III: topic (R. Boltshauser)**

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Students who do not wish to change the design class don’t have to participate in the internal enrolment.

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only.

This is also the ultimate deadline to unsubscribe or enroll

**Fostered competencies**

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</tr>
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<td>Decision-making</td>
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</tr>
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<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
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</tr>
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<td>Decision-making</td>
<td>Problem-solving</td>
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<td>Project Management</td>
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**Lecture notes**
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**Literature**
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**Prerequisites / notice**
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The design studio is structured as a year-long course.

The submissions during the autumn semester will be individual work.

**052-0545-22L Architectural Design III: topic (R. Boltshauser)**

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Students who do not wish to change the design class don’t have to participate in the internal enrolment.

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only.

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**Prerequisites / notice**
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The design studio is structured as a year-long course.

The submissions during the autumn semester will be individual work.
This studio will be organized in 3+1 movements of three weeks each:

Architectural Design III: Do we live a house or house a life? (J. De Vylder)

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php). Students who do not wish to change the design class must not enrol.

Project grading at semester end is based on the list of enrolments on 11.12.22 (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

This studio will be organized in 3+1 movements of three weeks each:
- Moments, Actor, Atmosphere, Condition

Objective

We study 3 times a combination of five topics. All together we will by that collect an endless series of configurations of topics.

Prerequisites / notice

Individual and group work, including 3 to 4 weeks of group work.

Introduction: 20 September 2022, 10:00 am, HIL F61
Intermediate crits: 15 - 16.10.2022
Final crits 20.12/21.12.2022
No extra costs

052-0547-22L

Architectural Design III: Do we live a house or house a W life? (J. De Vylder) 14 credits 2V+14U J. De Vylder, D. Mettler, D. Studer

- Examination of the condensed, sustainable, circular, simple building process
- Development of a broad theoretical basic knowledge
- Holistic design of spatial atmospheres in the interplay of concept, context, construction, climate, sustainability and materiality
- Research and development of architectural themes resulting from energy and climate considerations
- Practical work on the model, plan and visualization program as part of the design process

Content

"Cities are fluid entities that are constantly changing. History leaves subtle traces, which become visible upon close inspection. The term "palimpsest" comes from the Latin "palimpsestos" or Greek "palímpsestos" and means "scratched off again". The original use of the word refers to an ancient or medieval piece of writing from which the original text was scraped or washed away and which was then reinscribed. The repurposing, demolition, or expansion of built structures leads to an overlay of different architectural styles and pragmatics that can be used as a repository of new ideas and approaches."

How exactly can the Geroldareal be understood as such a storage facility?

The great variety of interesting uses, the fertile breeding ground for new ideas and their implementation, the palpable openness and the creativity across all sectors are just a few of the characteristics that make the Geroldareal an important and identity-forming place in the city of Zurich for many people. It is important to preserve and promote such a place and not to destroy it with unsuitable or simply bad projects. For us architects, the question is therefore how the area can be redensified and its qualities preserved or even expanded at the same time. How do we ensure that less affluent uses can also keep or find a home in the center of the city? What kind of densification can the area tolerate or even promote its resistance? How can a coexistence of different users be achieved in order to further exploit the potential of the area?

Initiated and accompanied by the city of Zurich, we are asking ourselves, together with the city, what the future of the Geroldareal can look like. We believe that it is characterized by various qualities - including the cultural-historical building fabric, the heterogeneous mix of uses and the spatial diversity. How, where, in what form and with what utilization can sustainable density be achieved at this location without impairing the existing qualities? Which structures can further exploit existing potential and strengthen the identity of the site?

The semester assignment aims to develop a project that shows an adequate solution for the site from an urban planning and architectural point of view. Starting from the urban analysis to an adequate handling and intervention in the existing building stock, we deal with the questions of sustainable building and especially climate-friendly densification. Starting with a precise analysis of the site, its history and characteristics, a charter defined in the group will be developed, with a clear attitude in relation to the existing structures and buildings. An important role is played by the lifespan of the intervention and the associated temporality. We understand the approaches of circularity - such as the prefabrication of elements and modules, component connections as nodes or reusable system construction methods - as important prerequisites for sustainable building and therefore want to integrate them integrally into the thinking and the design process from the very beginning. In addition, we also deal intensively with the aspects of lightweight construction in interaction with circularity and critically question concepts of additions, new buildings, extensions and conversions in order to gain a profound understanding of the process and the associated key figures in terms of sustainability.
Content

Do we know HOW we live? Do we know enough about HOW we live? HOW do things around us shape the way we live? HOW do we live the things around us? WHAT are the conditions around us? WHAT makes our habitats? HOW do habitats change conditions? 7 MOMENTS

How do we cook? HOW do we bath? HOW do we rest? HOW do we move? HOW do we plant? HOW do we store? HOW do we work?

Is the way we cook defining the space or is our space changing the way we cook? Is taking a bath a matter of physical cleaning or might it also be a matter mental health? Do we sleep to rest or is the bedroom also a place to read, to play, to meet? What more can space be than just circulation? HOW do you crop? WHAT do you store, where do you hide? WHAT is an office at home? WHAT is work at all? HOW is everything about life? HOW to live life?

7 ACTORS: How do we perceive space differently from being a child to being elderly? Are gender and culture what change it all? HOW do we share? HOW do we invite? HOW do we host? HOW do we care? HOW do we cohabitate? 7 ATMOSPHERES: What is the meaning of color and light, of smell and texture? WHAT do you feel?? WHAT do you hear? HOW much can you see? WHAT is familiar to you? WHAT brings you joy? 7 CONDITIONS: Day, fog, night, rain, snow, wind. HOW does our life differ with weather and climate? HOW does our mood adapt? 7 OBJECTS: How do we perceive space differently from a chair to a wheelchair? IS the window the key element to define space? WHAT role does nature play? Where do you warm up? HOW to design a chair? WHAT is a good door?

Where lies your attention? Do we live a house? Or do we house a life? HOW. Do. We. Live. 3 + 1 This studio will be organized in 3+1 movements. Each of the 3+1 movements will last 3 weeks. For the first 3 movements, students will work in groups of 3. These 3 students become a practice. The practice will be assigned 1 out of 7 MOMENTS + 1 ACTOR, 1 ATMOSPHERE, 1 CONDITION, 1 OBJECT-by chance. In the next movement group members and assigned MOMENTS change again. Each other movement will be another group constellation of students. The lottery of words starts from the beginning. We study 3 times a combination of 5 topics. All together we will by that collect an endless series of configurations of topics. The +1 movement will be an individual movement of collection - piling up the 3 MOMENTS to a composition as décor for a story of life. The study will be given an image by big models and drawings. Always plans, sections and elevations, and also isometric drawings and construction details are the expected outcome. 7 MOMENTS, 7 ACTORS, 7 ATMOSPHERES, 7 CONDITIONS, 7 OBJECTS A set of reference documents is made available. It ranges from standards and norms to inspirational and provocative references. Architecture, art, text, everything ... life.

Prerequisites / notice

Individual and group work, including 5 or more weeks of group work.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
  - assessed
- Project Management
  - assessed
- Cooperation and Teamwork
  - assessed
- Sensitivity to Diversity
  - assessed

Method-specific Competencies
- Negotiation
  - assessed

Social Competencies
- Adaptability and Flexibility
  - assessed
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - assessed
- Self-awareness and Self-reflection
  - assessed
- Self-direction and Self-management
  - assessed

Personal Competencies

Fostered architectural and social competencies.

Method-specific Competencies
- Project Management
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Architectural Design (from 5. Semester on)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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- Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).
- Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.
- Inspired by Louis Kahn's passionate and enigmatic interest in institutions and their origins, the aim of this studio is to investigate the possibility of a primordial architecture. A search for a "small" but essential architecture, able to define the character of an institution.
- Managing environmental conditions of a site (orientation, appearance, circulation, resources, pre-existences, etc.).
- Having the ability to rethink the pre-established and the interest to discover unknown approaches.
- Incorporating an emotional approach to architecture – designing from experience.
- Controlling and articulating the various qualities of space (dimensional, material, environmental, etc.).
- Integrating the physical behaviour of a building as a fundamental part of the project.
- Designing with natural systems and thermodynamics to create spaces with "real" comfort.
- Re-learning how to live and build in future climate paradigms. - Learning how to find expressions and characters of spaces through the use of matter.
- Understanding the potential offered by construction systems a technology.
- Combining technical decisions with formal ones in a significant way. - Detecting opportunities to give innovative answers to the relationship between buildings and nature.
- Incorporating interdependence as a determining factor in the design of buildings.
- Organizing the work in a way, which is appropriate to the available qualified documents in different formats, contexts, and medias with an explicit focus in working with physical models.
Inspired by Louis Kahn's passionate and enigmatic interest in institutions and their origins, the aim of this studio is to investigate the possibility of a primordial architecture. A search for a "small" but essential architecture, able to define the character of an institution. What is substantial? What is really defining a theatre, a library, or a school? We are looking for new approaches that transcend the functionality of pre-established programs and discover their hidden nature, the invisible condition that characterizes each type of space and institution.

We aim to redefine and rediscover the architecture of the institution, "an organism that carries out a function of public interest" (according to the dictionary), "a world within the world", "a center around which existential space is organized" (according to Kahn).

The Studio will take place in a specific location in Zurich: a small but complex plot, cohabitating with various pre-existing elements that surround and condition it. Each student will be assigned one of these possible institutions:

- Library - Museum - School - Temple - Town Hall - Market - Theatre - Hospital - Bath - Courthouse

The chosen site is voluntarily small - smaller than could be expected. The lack of space must be a positive condition, forcing us to take radical decisions. Necessary steps to discover the essence of the space: what is a priority, far from inherited or pre-established solutions.

To design the primordial (what really defines a place and the institution) we will need to go back and free ourselves from a part of what we have learned. To re-investigate the genesis of human activities, the sources and origins of what has historically set architecture.

This research requires a critical positioning. A confrontation with the established form, what could be a convention or just a trend. A fight against the status quo to allow us to redefine our values and our priorities, to discover the indispensable that qualifies as architecture. We propose to deconstruct the great institutions, extracting the insubstantial and unnecessary to find their most elemental definition, their substance.

In the design of a new "small" institution, as in a good poem, it will be necessary to synthesize, reconstruct and retain only the fundamental. To find what awakens the most emotional dimension of architecture. What is necessary and unnecessary. What supports its meaning, its form, and its character. How is it built. What is it made of. How it behaves. It will be a precision exercise: learn to prioritize.

The reduction to the essential does not mean giving up ambition. It is an opportunity to find the most decisive expression of architecture (where nothing is superfluous or missing). A unique architecture that remains convincing over the years. Architecture that transforms inert matter into something vivid and extraordinary.

We will look for architecture that activates these processes from a pragmatic and reciprocal approach. From thermodynamics and interactions with the environment to the structure and tectonics of construction techniques. From space composition to social behaviors. Everything necessary to design and calibrate exceptional spaces. Spaces of inspiration, precision and interdependence.

Pre-institutions (or small primordial institutions) that redefine our priorities. A soft but radical plot twist, that perhaps can show us a different understanding of architectural space.

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Pre-institutions (or small primordial institutions) that redefine our priorities. A soft but radical plot twist, that perhaps can show us a different understanding of architectural space.
Abstract
This studio works on the idea that a substantial understanding of today's technology (internet of things, big data, machine intelligence ...) changes the perspective to architectural theory and will result in different architectural designs and building Constructions.

Objective
1) Identification and understanding of the challenges of today's technologies;
2) techniques of working within the plenty of the internet;
3) a methodology to design digital architectures;
4) understanding of the shift from hard building construction to soft building applications, and
5) an understanding of the importance of becoming a literate digital persona in order to be an architect today.

Content
METEORA #07 will use artificial intelligence to write a text to explicate a precise position in today's world, to create a spectrum of images to reflect this world and design an architectural artefact which brings things into adequate proportions.

Prerequisites / notice
Individual work only.

Intermediate crits: Dates will follow.
Final crits: 20./21.12.2022
No extra costs.

Architectural Design V-IX: Borderline Investigation #8
(14 credits) W 16U A. Theriot

WHY 19°C?
The definition of 19°C as ideal minimum interior temperature is based on the equation of Fanger from the 70s. A complex, physiological, psychological and socio-culturally constructed sensation, the feeling of comfort is fragmented into quantifiable parameters. The norm defines well-being as the state of neutrality. The moment, where the thermoregulatory system remains passive, the equilibrium. After Fanger, the average „standardized subject“ will feel neutral at 19°.

There is, up to today, no health-based evidence to avoid the stimulation of the thermo-regulatory system.

WHO OR WHAT IS STANDARD?
A standard person according to current knowledge corresponds to a normal-weight healthy man between the ages of 25 and 30 years. A counter case study shows that depending on the environmental conditions the calculation with a standard person has a high risk of error according to EN ISO 8996.

WHY REMAIN NEUTRAL?
What if we would include the sensation of slightly warm and slightly cold in the comfort zone? how much heating energy would we save if we would consider instead 18°C as the minimum indoor temperature? and how much would the carbon footprint be reduced, if we would allow for higher seasonal fluctuations of temperature, thus use less layers of material/ isolate less? what if, instead of conditioning the buildings, we would control less and start to condition/change our behavior?

The examination of the contemporary „instruments of comfort“ implies revealing them as part of a consumption network we can no longer ignore. To question their capacities might lead to a new, more fragile, even impure, understanding of comfort – guarantee of a dynamic space.

TOKYO AS A CASE STUDY:
With a different eye on the notion of comfort, we will explore Japan and in particular Tokyo as a case study of this condition. Questioning our relationship with our environment, accepting it rather than trying to fight against.
We aim to seize economic requirements to transform constraints into levers, producers of qualities. These may well be tangible or intangible, prosaic or poetic, constant or unstable, general or occasional. As long as they are initiated by the economy and located far from any rationality. Creating generosity, “excesses” that make the strength and uniqueness of a place.

The semester will unfold in three chapters:

CHAP 1: MYTHOLOGY
CHAP 2: FINDING FREEDOMS
CHAP 3: BINDING FRAGMENTS

INTEGRATED WORKSHOPS:

Fragmentin (artist)
Olivier Campagne (3D visualisations)
Lluis Enrique (structure)
Gontran Dufour (facade and envelope)
+ further external experts from the fields of cognitive sciences, economics and politics to be confirmed

EVALUATION CRITERIAS:

- RESEARCH: 3
- NARRATIVE: 3
- TERRITORIAL STRATEGY: 2
- USES/PROGRAM: 1
- REPRESENTATION: 2
- TECHNICAL SOLUTION: 2
- TYPOLOGY: 2

INTEGRATED SEMINAR WEEK
Integrated seminar week to Tokyo will take place from 20.10 to 31.10.2022 (TBC)
Cost category C: 750CHF (incl. transport and accommodation)

It is highly recommended to students enrolling to our studio to also enrol and take part in the integrated seminar week, as we will visit together the different project sites, and much more exiting experiences.

Students enrolled are responsible of having their valid passport and vaccination certificate on the first week of the semester, in order to complete visa applications.

Prerequisites / notice

- Group work only.
- Introduction: 20 September 2022, 10:00 am, Old Garden behind the chemistry building
- Intermediate crits: 18.10.2022, 15.11.2022
- Final crits: 21.12.2022
- Extra costs: Approx. CHF 150.-- per student.

Architectural Design V-IX: Life on Earth (T. Emerson)

052-1115-22L
14 credits
16U
B. Gusic, T. Emerson

Content

Life on earth is a precarious business. But so far, it is the only option we have. We have learned to make the most of it. But we have built too much. Centuries of over production and extraction have turned into a crisis. It is a cruel irony that our era of over extraction is being solved by doing more, not less. More insulation, more mass, more timber, more earth, more renewable, more sealed, more closed. Yet the stories of human culture and architecture has always returned to its most basic form in times of crisis and celebration. The tent turns setting into settlement in an instant and for an instant. It is ceremonial for queens and kings, celebratory for weddings and festivals, technical for explorers, desperate refuge for the displaced or simply everyday life. The tent is the origin of architecture and its ghostly memory. The tent remains the quickest way to produce space with lightest of material means. This semester, we shall design and build a landscape and a tent. We shall attempt a return to the fundamental values of architecture at a time when critical worldly issues conspire to push architecture to the margins. It will engage form, making and craft. We shall create both the landscape and the space from material, plants and ground that already exist. As Bruno Latour has repeated, design is only ever re-design. Materials will be re-used and landscape transplanted for a lighter collective life.

Prerequisites / notice

- Group work only.
- Introduction: 20 September 2022, 09:00 am, Old Garden behind the chemistry building
- Intermediate crits to be anounced
- Final crits to be anounced
- No costs

Abstract

Life on earth is a precarious business. But so far, it is the only option we have. We have learned to make the most of it. But we have built too much. Centuries of over production and extraction have turned into a crisis. It is a cruel irony that our era of over extraction is being solved by doing more, not less. More insulation, more mass, more timber, more earth, more renewable, more sealed, more closed. Yet the stories of human culture and architecture has always returned to its most basic form in times of crisis and celebration. The tent turns setting into settlement in an instant and for an instant. It is ceremonial for queens and kings, celebratory for weddings and festivals, technical for explorers, desperate refuge for the displaced or simply everyday life. The tent is the origin of architecture and its ghostly memory. The tent remains the quickest way to produce space with lightest of material means. This semester, we shall design and build a landscape and a tent. We shall attempt a return to the fundamental values of architecture at a time when critical worldly issues conspire to push architecture to the margins. It will engage form, making and craft. We shall create both the landscape and the space from material, plants and ground that already exist. As Bruno Latour has repeated, design is only ever re-design. Materials will be re-used and landscape transplanted for a lighter collective life.

Objective

- Designing and making 1:1 as a collective
- Working with temporality
- Re-use and bricolage
- Finding tools of engagement for an ecological architectural practice
Rotterdam has 655,000 inhabitants on a total area of 324km² (216km² land/108km² water), the density of 2022 inhabitants/km² is only half that of Zurich. Population growth is estimated at 695,000 inhabitants in 2030, similar to Zurich at 5,500 inhabitants/year. The demand for housing (50,000 by 2040), commercial and office space, schools and leisure/cultural uses is high and is to be met by transforming the harbour areas into mixed-use quarters in the city centre. Large green and park areas as well as a catalogue of sustainability measures regarding community, mobility, biodiversity, heat reduction and alternative energies play an important role.

We want to address the challenges of sustainable densification of the growing city and design quality buildings in different scales that respond to the specific places and enrich the Maashaven. The relationship to the water, the formation of the base with public uses and its interconnection with the neighbourhood is essential. The focus is on mixed-use and affordable housing, which is to be developed together with commercial, office, leisure and cultural uses into conglomerates of uses with hybrid forms. The load-bearing structures are generously dimensioned, thus neutral in use and polyvalent. The access routes are differentiated, varied and extended with places for community.

They are intended to be experimental solutions that make innovative social offers, find a good balance between durability, low ecological footprint and material consumption, and reduce the carbon footprint.

Together with the Block Research Group, we focus on efficient, lightweight load-bearing structures to significantly reduce grey energy and CO₂ emissions. Corresponding calculations help us in our design decisions.

With the prefabrication of load-bearing structures, core elements, façades and other components, we make a contribution to the circular economy in that components can be dismantled and reused at the end of their service life. In the case of new buildings on or near the water and in dealing with existing industrial buildings, as well as through the stacking of rooms of different sizes in section, structural challenges arise such as spans, stepping and cantilevers, which are to be carefully weighed in relation to effort and return.

The goal is expressive architecture that is present, convincing and emotionally moving. Lectures on Rotterdam, inputs on waterfront development and sustainability as well as workshops for design-defining visualisations will support us in the design process.

The projects will be discussed at interim and final critiques with guests and the chair in the range of concept idea, urban embedding, development and sustainability as well as workshops for design-defining visualisations will support us in the design process. Lectures on Rotterdam, inputs on waterfront development and sustainability as well as workshops for design-defining visualisations will support us in the design process.

The projects will be discussed at interim and final critiques with guests and the chair in the range of concept idea, urban embedding, development and sustainability as well as workshops for design-defining visualisations will support us in the design process. Lectures on Rotterdam, inputs on waterfront development and sustainability as well as workshops for design-defining visualisations will support us in the design process.
“Architecture is a temporary answer to a temporary need.” reads the plaque at the foot of the tower. Few people know the inscription, which has been the subject of as much controversy as of myths and conspiracies. If you ask the residents of Zurich to-day what the windowless tower is all about, you will hear different stories. Politics of fear. Architecture of crisis. Politics of precaution. Architecture for the future. What these stories teach us is that history is subjective, and we decide which narrative we choose in order not to understand the present, but also to anticipate the future and open it up for imagination.

Between Fact and Fiction: Switzerland has a long tradition of preparing itself for crises. Thus, one could say that the Swissmill tower is one of many architectures and infrastructures for potential emergencies, based on past and current concerns, such as the scarcity of food for the Swiss population. In order to guarantee the supply of grain for a wider Zurich population, the silo tower shall officially serve as a long-term storage facility. The biggest bank in Zurich, one could say.

Swissmill processes 800 tons of grain a day, equaling 30% of the Swiss national grain requirements. Located in the center of Zurich, its 118 meter high concrete tower serves as a grain elevator and is the tallest of its kind worldwide. Every morning, around 1.000 tons of grain are delivered, equaling four wagons of packed flour and multiple wagons of bran pellets. The almost hollow volume houses 48 square cells along the newly built perimeter walls that can store up to 40.000 tons. The tower was built on top of the original Kornhaus, more precisely over it, bringing the gigantic loads into the pile foundations.

Due to its presence and appearance the Swissmill tower has triggered an ongoing debate on the construction of high-rises in Zurich, bringing together social, ecological and economic aspects. From the need of housing, over the environmental consequences of construction, to the speculative potential of investment. A heated debate that finds its continuation in the new high-rise regulation that shall be implemented in Zurich and would allow for unlimited high-rise construction within the city. Thanks to the Swissmill tower, one could say.

Architecting Hidden Futures: Consequently, rumors persist that the process leading up to the construction of the building was an orchestrated act, aimed at architecting the conflicting interests of a growing Zurich population. Therefore, an alternative future use was inscribed in the building. In order to get permission, the owners – Swiss wholesale company Coop – had to follow a new regulation which states (excerpt):

§4; Abs. 2: “[…] consequently the permission shall be deemed under the condition, that a future use for the common good […] must be inscribed in the building […] as the demolition of any built structure won’t be allowed by 2029 […]”

Beyond its present function as a silo and grain tower, the building was always meant to play different roles: as a social moderator, an ecologic case study, an economic value generator, a political design tool. The tower is therefore only one concrete manifestation of a series of topics: bigger in scale and importance, then the architectural object or local manifestation.

Both learning objectives will be introduced in topic-specific lectures at the beginning of the course.

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).
Architecture embodies duration and time. It contains the temporality of everyday activities, of small and large maintenance as well as assessed
\[ Insights into temporal forms of building \] assessed
Architectural Design V-IX: Madagascar Hand Made assessed
14 credits assessed
Assessed
Adaptability and Flexibility assessed
16U assessed
In the semester, we ask: is there also an ecological form of temporariness? Temporary architectures reflect our growing need for lightness, assessed
freedom, independence, and flexibility. Their provisional nature, speed, adaptability, and simplicity seem much more in line with increasing assessed
mobility and multiple lifestyles. assessed

Abstract
In the semester, we ask: is there also an ecological form of temporariness? Temporary architectures reflect our growing need for lightness, assessed
freedom, independence, and flexibility. Their provisional nature, speed, adaptability, and simplicity seem much more in line with increasing assessed
mobility and multiple lifestyles. assessed

Objective
- Insights into temporal forms of building assessed
- Knowledge about social, economic and ecological issues in Canton Ticino assessed
- Design of new forms of housing assessed
- Constructive knowledge assessed
- Models in different scales assessed
- Experimental photography assessed

Content
Architecture embodies duration and time. It contains the temporality of everyday activities, of small and large maintenance as well as assessed
necessary repairs and renewals to protect against weathering and decay. Since the 1970s, short-liveness found its breakthrough in the assessed
building sector, as industrialization provided construction materials as products with expiration dates and short renewal cycles (Uta Hassler, assessed
2011). This economically driven form of short-liveness came at the expense of sustainability. In the semester, we ask: is there also an assessed
ecological form of temporariness? Temporary architectures reflect our growing need for lightness, freedom, independence, and flexibility. assessed
Their provisional nature, speed, adaptability, and simplicity seem much more in line with increasing mobility and multiple lifestyles. It is not assessed
for nothing that Zygmunt Baumann in 2003 called «fluidity» as appropriate metaphor to describe the «specificity of our present». We assessed
consider architecture as a «volatile mixture of time and substance» (Ákos Moravánszky, 2020). Processes of liquefaction and solidification assessed
shape our search for a new ecological aesthetic. We distinguish two types of temporary buildings: ephemeral houses made of perishable assessed
materials, which - as soon as they are no longer used - decay on site. Nomadic structures, made of long-lasting materials, which are assessed
continuously dismantled and rebuilt. The Canton of Ticino as a border region, between the Alps and the great lakes, its specific weather assessed
and climate conditions, its great seasonal and daily population fluctuations, its economic and ecological reality, forms the territory of our assessed
interventions. We ask in which architectural projects narratives of the temporary manifest themselves. We start the semester with a full- assessed
day excursion to Canton Ticino and exchange with local experts. After an initial research on the narratives, the students build an assessed
architectural detail on a scale of 1:10 as a tool and model of a material and constructive understanding of the temporary. The architectural assessed
projects programmatically address temporary housing. During the semester, we collaborate with the team of building technology and assessed
construction (BUK), as well as with Guillaume Habert’s chair of sustainable construction. In workshops with the artists Taiyo Onorato and assessed
Nico Krebs we create experimental images of the projects. assessed

Prerequisites / notice
BUK as an integrated discipline is included in this course. assessed

Group work only. assessed

Introduction: 20.09.22, 10:00 pm, HIL F75 assessed
Intermediate crits: 12.10.22, 15.11.22 assessed
Final crits: 20.12.22 assessed
Extra costs: Approx. CHF 100.-- per student. assessed

052-1127-22L Architectural Design V-IX: Madagascar Hand Made (Girot) ■ assessed
Please register (www.mystudies.ethz.ch) only after the assessed
internal enrolment for the design classes (see assessed
http://www.einschreibung.arch.ethz.ch/design.php). assessed

Project grading at semester end is based on the list of assessed
enrolments on 1.11.22, 24:00 h (valuation date) only. This assessed
is the ultimate deadline to unsubscribe or enroll for the assessed
studio. assessed

Abstract
The Landscape Architecture Studio in the Fall 2022 will investigate innovative designs for flood relief in Antananarivo. It will address assessed
the peri-urban context of the city that is subject to severe seasonal flooding. The site-specific approach includes modeling of resilient assessed
landscape infrastructures to enhance the safety of neighborhoods located on the banks of the Ikopa and Sisaony rivers.
The capital city of Madagascar, Antananarivo, is a high-altitude city. Urban growth is changing rapidly the traditional landscape of the Merina culture dominated by rice cultivation in the plains, as informal settlements are more and more occupying the rice plain. This uncontrolled growth also increases the demand for local bricks produced from soil mining, degrading the existing agriculture. In addition, there are back-fills that eat away at the capacity of the city to cope with flooding. As a result, the infrastructures coping with floods in the city are no longer adequate. Many canals originally built by rulers for irrigation purposes are now embedded in the urban fabric and have been subverted into open air sewers. The proximity of rice fields with the informal settlements creates added difficulty for farmers to organize irrigation or to cope with city’s effluents on crops. Madagascar is one of the poorest countries in the world. These challenges bring an opportunity to construct a resilient and more sustainable landscape environment for the city, capable of integrating urban growth with measured flood management and sustainable food production.

The studio will propose a series of new designs for an agro-urban flood-food landscape adapted to the present situation. The intention would be to develop designs that integrate food and irrigation management while keeping key benefits that city dwellers get from their local ecosystem. This will be achieved through the enhanced capabilities of 3D point cloud modelling and design. The design of significant landscape changes in Antananarivo draws from a combination of design and analysis methods to find adaptive solutions. These design tools supported by scientific feedback will initiate an iterative process between capturing, analyzing and visualizing possible futures. The designed landscape scenarios developed by the students will be assessed in their performance and feasibility according to pluvial model simulations and the ecosystem services they provide. New landscape designs will be integrated to flood- and food-resilient scenarios urgently sought by Malagasy society. The studio philosophy is to build on the strengths of the current socio-ecological interactions that exist locally. The studio will aim at bridging design, engineering and science, by promoting novel ways to transform urban landscapes in the context of Antananarivo, providing more resilient habitat for citizens living under severe climate and socio-economic changes with a particular focus on local food production.

The subject is the Amsteg power plant and its empty machine hall. Amsteg is a place of passage on the Gotthard axis, which spatially and architecturally has been subverted into open air sewers. The proximity of rice fields with the informal settlements creates added difficulty for farmers to organize irrigation or to cope with city’s effluents on crops. Madagascar is one of the poorest countries in the world. These challenges bring an opportunity to construct a resilient and more sustainable landscape environment for the city, capable of integrating urban growth with measured flood management and sustainable food production.

The studio teaches how to understand an existing building through analysis in its constructive spatial contexts and how to use it as a repertoire and trigger for design. Through targeted inputs, students experimentally practice translating structural features and principles into spatial programmatic and constructive statements and incorporating “discoveries” as part of the design process. Relating to the existing constructive concepts that are experimentally translated into spatial ones. The existing building represents an anchor and at the same time a fund, which we make productive in terms of design and thinking of design in temporality means taking a stance on the history and contemporary issues of place. With the design and representation techniques taught, the project finds a coherent and profiled statement.

Literature

Booklet and reader will be delivered at the beginning of classes.

Prerequisites / notice

Work in teams of 2 is advised.

Introduction: 20.9.22, 10 am, HIL C 40.1
Midterm crits: Dates will follow
Final crits: 20./21.12.2022

Integrated (obligatory) seminar week to Antananarivo (22.-30.10.2022)
(Costs: CHF 699.--).

Number of participants: 15 students.


W 14 credits 16U C. Menn

(GD Menn)

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract

Buildings are physical repositories of the history of their time and place. In the Alpine region, various buildings have lost their function and meaning in the course of their lifetime for different reasons of structural change.

Objective

The studio teaches how to understand an existing building through analysis in its constructive spatial contexts and how to use it as a repertoire and trigger for design. Through targeted inputs, students experimentally practice translating structural features and principles into spatial programmatic and constructive statements and incorporating “discoveries” as part of the design process. Relating to the existing and thinking of design in temporality means taking a stance on the history and contemporary issues of place. With the design and representation techniques taught, the project finds a coherent and profiled statement.

Content

Buildings are physical repositories of the history of their time and place. In the Alpine region, various buildings have lost their function and meaning over the course of their lifespan for various reasons of structural change. We deal with an alpine architectural wasteland of artistic performance. We discuss questions about the form of memory, public appropriation and sensuality of space.

The subject is the Amsteg power plant and its empty machine hall. Amsteg is a place of passage on the Gotthard axis, which spatially impressively bundles alpine cultural and technical history at a pronounced narrow point of the valley. The Gotthard railroad, built in 1872, was electrified in 1922 by the Amsteg hydroelectric power station. Around the turn of the millennium, the NEAT generation project and the Gotthard Base Tunnel demanded a significant expansion of SBB’s own electricity production, which is why a new power plant in a rock cavern replaced the Amsteg powerhouse in 1998. Since then, the building of the imposing complex has stood empty.

By using it for different forms of theater, we are developing a new public sphere. While theater describes the perception of space as a phenomenon of movement between subject-body and space-body, we ask what relationship the new enters into with the existing architecture and what spatial qualities the different actors create. In gradual scales we work with the physical model and model photography as a medium of image fixation. The studio is accompanied by BUK, an integrated construction is offered.

Prerequisites / notice

Construction as an integrated discipline is included in this course.

Individual and group work, thereof 1 to 2 weeks of group work

Introduction: 20 September 2022, 10:00 am, HIL F61
Intermediate crits to be announced
Final crits to be announced
Extra costs: Approx. CHF 50.-- per student.
Departing from elementary observations by French writer Georges Perec in his book Species of Spaces we will develop a critical reading and engaged writing of places to dwell. We will approach architectural precedents as a repository to learn from and open up dialogues with. We will reflect on dwelling types, their past and present relevance and their potential meaning to address current needs. We will engage with a number of building sites to explore and project ideas of contemporary dwelling, by designing buildings or ensembles to dwell in. We will take the time to get up close and personal with both references and proposed sites. We love to walk, over and over again and at different times of the day; to wander around our sites; to work in them, dwell in them, read in them, touch and ignore, to understand but also feel and experience them through our own bodies and biographies. By walking, building, drawing, reading, smelling, listening, touching and ignoring, we will, together with you, use the semester to dwell on Standards of Living.

The focus of this semester is to challenge the possibility of glass as a building material, questioning its predominant architectural use as a pictorial frame, and site to reimagine what can be gained and achieved with glass as a space-defining material.

This speaks in stark contrast to the writings of Beatriz Colomina on Adolf Loos, where she details his aversion to transparency, believing that the material engagement in a spatial way, based on the full potential of the inherent qualities of the material itself and your way of working with it. 

In this design studio, you will define your gestures of making and working with material(s) through research and experiment, and in response to the topic of the studio. You are required to produce an architecture that results from your specific engagement with the material and the spatial condition you construct with it. The architecture that results from this approach does not reference or represent something, but simply attempts to exist as a physical spatial reality in its own right.

Your research should be supported by the knowledge made available by our studio, and engaged through you with the use of available resources and facilities at departments of the ETH and from external specialists.

### Prerequisites / notice

- **Group work only.**
- **Introduction:** 20 September 22, ONA, 2nd floor, end of corridor
- **Intermediate crits:** 19 October 2022 / 22 + 23 October 2022
- **Final crits:** 20 + 21 December 2022
- **Extra costs:** Approx. CHF 50.-- per student without seminar week
### Prerequisites / notice
- Individual and group work, thereof 5 or more weeks group work.
- Introduction: 21./22.9. at RIA (ONA-Building) and in Basel
- Intermediate crits: To be announced.
- Final crits: 20./21.12.
- No extra costs.

### Architectural Design V-IX: Topic (N.N. GD) ■

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**Abstract**
- Does not take place this semester.
- Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

**Objective**
- To follow

**Content**
- To follow

**Prerequisites / notice**
- To follow

### Architectural Design V-IX: To adapt (M. Conen) ■

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**Abstract**
- We will start with the conversion of furniture in our studio: six chairs. In the first weeks, we will work on adapting these chairs to new requirements and opening up possibilities through the use of other materials. We see this as your first contact with the topic of living and adapting. Subsequently, we will deal with a specific type of Zurich housing: the urban villa.

**Objective**
- Learning from and observing the existing objects
- Building upon what is there
- Relationship between garden and home
- Re-use and re-think
- Subtle and sensitive responses

**Content**
- To adapt means to change something that already exists. Not to make something new from scratch, but to create a new starting point by adapting what is there. This can be done slowly — perhaps cautiously — while anticipating what might come, but also intuitively and quickly. Recognising the potential and seeing its possibilities is essential in order to reuse and rethink the existing. And this, in turn, is vital when fostering a sustainable relationship with our environment. Adapting, rebuilding, extending, modifying, transforming - what should one adapt to? Is it adapting to new standards, requirements or functions? What are the new conditions and parameters we want to align ourselves with? Ultimately, it is about finding a creative way of dealing with things that exist and which we change to respond to new conditions and ideas. Adapting often involves challenging existing conventions and ideas. We will start with the conversion of furniture in our studio: six chairs. In the first weeks, we will work on adapting these chairs to new requirements and opening up possibilities through the use of other materials. We see this as your first contact with the topic of living and adapting. Subsequently, we will deal with a specific type of Zurich housing: the urban villa.

**Prerequisites / notice**
- Group work only.
- Introduction: 20 September 2022, 10:00 am
- Intermediate crits: 28.9 / 18.10 / 15.11
- No costs

### Architectural Design V-IX: Roots, Shaping African Urbanities (H. Klumpner) ■

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**Abstract**
- Does not take place this semester.
- Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

**Objective**
- Teaching Languages: English and German

**Content**
- Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

**Prerequisites / notice**
- Students will emerge in our Chair’s “urban method-design” to step by step develop their individual prototypical design projects. They will address both architectural urban scales and will be guided to collaboratively develop a baseline scenario. Mapping, identifying existing and future challenges and opportunities, students will take the role of stakeholders and translate their demands and resources into different scenarios. They will design urbanistic concepts and translate them into an evidence-based prototypical architectural project-intervention. This prototype is the synthesis of a process in time and space on different scales. The design project will be framed as a narrative that is consequentially visualized and communicated in analogue and digital graphic representations. Conceptual ideas will be co-developed with partners of Kigali’s Department of Architecture and local students, overlapping research questions with policies and guidelines of the Kigali Green City Pilot Project.
The basic thesis for this Studio Fall Semester 2022 is the design of a prototypical Health Care Center in Kigali, integrating socio-economic networks, promoting health, education, and the wellbeing of communities in alignment with Rwanda’s Green Growth, Innovation, and Climate resilience -strategies.

By 2050 the global population will change from 70 % rural to 70% urban population, particularly in Asia and Africa. The State of African Cities report, produced by UN-Habitat in 2018 show, that foreign direct investment, if distributed into secondary cities, and smaller towns, could promote growth of local economies, and that decentralization could impact inequality, poverty, employment, and food security on the continent.

Kigali city has been shaped by postcolonial urbanism, post-conflict-state building, and neoliberalism. Since the 1994 Genocide, Rwanda’s government has rewritten its history, setting strategic frameworks to promote, social cohesion, unity, and peace. Processes towards the restoration of human dignity are reflected through community programs, dialogue, economic and structural reforms. Strong governance, the revision of policies, masterplans and regulated urbanisation relate to interdependent development drivers that accelerate innovation, integration, agglomeration, and competition. Providing access to basic resources like clean water, electricity, education, healthcare, and sanitation facilities to all citizens, stresses the need to reduce widespread poverty and promote a middle in comes society by 2035. The landlocked country's economic growth and attractiveness drive in the East African Community is supported by a ban on plastic bags since 2008, and making use of 21st-century technologies. Kigali has re-designed itself to be Africa’s model gateway city, a global example for implementing environmental cleanliness and leapfrogging future-oriented IT and startup sectors.

The studio is an opportunity to engage in global south challenges, to imagine and model sustainable urban scenarios and to articulate a transformative architectural response interrelating the quality of the built and natural environment with systems of health and wellbeing.

In collaboration with the University of Rwanda’s Department of Architecture (SABE) in Kigali, we put studio envisions trans-scalar processes and small-scale interventions, addressing the city’s social and ecological challenges. The parameters of Kigali’s urban development and Green City Pilot Agenda will be translated into selected sites, sustainable systems and placemaking.

The studio applies a systemic urban design methodology, responding to the urgent need for concrete projects that promote the well-being of communities, climate action, and the UN’s SDG targets. Policy recommendations and general advice to upscale prototypical concepts are already successful in other cities globally and apply to the Kigali Case.

At the interface of architecture, urban landscape design and art, design can create a measurable impact in cities increasing social justice, health, and wellbeing. The development of robust frameworks in environments that are adaptable to change, can enable process driven growth, long-term operational, environmental and social benefits in response to global, local, and site-specific conditions.

The class material can be downloaded from the student server.

Lecture notes

“Urban Method-design”: Systematically engaging students in the Studio topic, to unlock their potential and skills towards developing prototypical design resolution on an urban and architectural scale. Identifying, understanding and developing local stakeholder networks, so as to translate challenges into opportunities and negotiate diverse interests into strategic ideas for development, geo-references, inter-linked systems, diagrams and maps. Develop design concepts for urban prototypes on different scales, framed by a narrative of a process that is consequentially visualized and communicated in analog as well as digital tools.

Investigative Analysis/ Local Perspective: Registering the existing; prioritizing challenges and opportunities through qualitative and quantitative information; mapping on different design scales and periods of time; configuring stakeholder groups; connecting top-down and bottom-up initiatives; idea mapping and concept mapping; designing of citizen scenarios.

“Project Design”: Synthesizing between different scenarios and definition of a thesis and program between beneficiaries and stakeholders; projecting process presentation as a narrative embedded in multiple steps; describing an urban and architectural typology and prototypes; linking systems, diagrams and maps. Develop design concepts for urban prototypes on different scales, framed by a narrative of a process that is consequentially visualized and communicated in analog as well as digital tools.

“Domain Shift”:: Shifting and translating different domains; testing and evaluating the design in feedback loops; including the project in the Urban Toolbox.

Literature

Reading material will be provided throughout the semester, as well as references to case studies. The class material can be downloaded from the student server.

Prerequisites / notice

Team:
Prof. Hubert Klumper
Anne Graupner, Diogo Figueiredo, Fernando Tulio | Chair of Architecture and Urban Design
Dr. Sibylle Wälty, ETH Wohnforum

In Collaboration with:
UIR | University of Rwanda, College of Science and Technology
SABE | School of Architecture and Built Environment
DoA | Department of Architecture

Dr. Manlio Michilietto, Dean of the Department of Architecture
Dr. Sandro Grispan, HoD, Studio Coordinator 5th year
Dr. Rahman Tafahomi, Studio Coordinator 4th year
Dr. Josephine Malonza, Studio Coordinator 3rd year
Phd. Cand. Alexis Sebarenzi Gatonzi, UN-Habitat

Seminar Week:
Travel to Kigali: 23.-30. October 2022

Organisation:
Architectural Design V-IX | ECTS Credits - 14
Integrated Discipline Planning | ECTS Credits - 3
4D-Geodesigning Urban Transformation

Recommended: Elective Course | ACTION! On the Real City: Drawing With Light

Language: German, English, Spanish and Portuguese
### Fostered competencies

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#### 052-1141-22L  Architectural Design V-IX: Reframe, Rearrange, Repeat (A. Caruso) 

**Abstract**  
This semester will be an intentional return to the tangible. Working on a group of buildings around Helvetiaplatz in Zurich we will make projects for additions and transformations that substantially increase the capacity of these buildings and explicitly embrace making architecture.

**Objective**  
Qualification to control the design process increasingly independent and with sole responsibility and to find to an individual design methodology and attitude.

**Content**  
This semester will be an intentional return to the tangible. Working on a group of buildings around Helvetiaplatz in Zurich we will make projects for additions and transformations that substantially increase the capacity of these buildings and explicitly embrace making architecture. Using models and drawings we will develop and represent an architecture that is connected to our discipline’s long history of forms and techniques at the same time as being relevant today.

Architecture that addresses our current predicament cannot only be a matter of upcycling and the adaptive re-use of existing structures. Although these are important themes, for architecture to continue to be culturally productive we need to discover the beauty that lies within the environmental turn. One way of doing this is to reframe the ways we think about cultural production and challenge the idea of the work of art as an autonomous entity. By engaging directly with the contingencies of material life, perhaps then, can we make a substantial and culturally engaged architecture of today.

To help us reframe how we think about architecture we will study the ideas and work of six artists: Édouard Manet and Richard Prince, Auguste Rodin and Rachel Whiteread, Louise Lawler and Andrea Fraser. While admittedly very different, they all developed their work in ways that challenged the formal, social and institutional expectations of their times. While their practices respond to the conditions of different times, they are still relevant and speak powerfully to us today. The ideas, as well as the formal and material qualities of these artists’ work will inform our search for an architecture and a beauty for the 21st century.

**Lecture notes**  
To follow

**Literature**  
To follow

**Prerequisites / notice**  
Planning as an integrated discipline is included in this course.

**Group work only.**

**Introduction:** 20 September 2022, 09:00 am Helvetiaplatz, next to the "Denkmal der Arbeit"

Intermediate crits to be announced

Final crits 20.12/21.12.2022

Extra costs: Approx. CHF 100.-- per student.
Fostered competencies

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Architectural Design V-IX: Voluptas S2E1 - Pathfinder

W 14 credits 16U F. Charbonnet, P. Heiz

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

Project grading at semester end is based on the list of enrolments on 1.11.22, 24.00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
Focus on the city of London: Rich history, possibilities. As the framework of our prospective investigation, it shall evoke an array of fantasies and trigger multiple narrative potentials.

Objective

Research & curation of contemporary concepts, articulation of a discursive argument, visual literacy & storytelling, image montage & composition, architectural drafting and projecting.

Incentives:
Agency & character, movies & scenario, territorial & urban scale, collectivity, situations & artefacts, socio-political dimension, critical position, contemporary conditions.

Steps:
(1) Analyze an urban territory, research contemporary concepts, identify potentials, articulate a critical position, conduct an objective survey and draft a path;
(2) Based on the survey, reduction of the path to its subjective experience, drafting of the resulting collection of architectural features in both plan and section; make use of the cinematic technique and the process of montage in order to suggest a storyline; project an urban scenario on both the artefactual and the territorial scale, focusing on collectiveness and the socio-political aspects of society;
(3) Epitomize/Idealize the experience-path in order to express a critical position towards contemporary conditions, negotiate and collaborate in order to mount a common map of intensities;
(4) Train rhetoric and argumentation, master drafting skills as well as image montage.
I imagined a labyrinth of labyrinths, a maze of maze, a twisting, turning, ever-widening labyrinth that contained both past and future and somehow implied the stars. Absorbed in those illusory imaginings, I forgot that I was a pursued man; I felt myself, for an indefinite while, the abstract perceiver of the world. The vague, living countryside, the moon, the remains of the day did their work in me; so did the gently downward road, which forestalled all possibility of weariness. 'The evening was near, yet infinite.' —J.L. Borges, Ficciones (1944)

PATHFINDER 1 will focus on the city of London: its rich history, morphology, mythology, possibilities... all canonic spatial perimeters as suggested by Lefebvre: political, sociological, anthropological, economical. As the framework of our prospective investigation, it shall evoke an array of fantasies and trigger multiple narrative potentials.

The careful and critical consideration of architectural paragons, socio-economical dynamics, geopolitical shifts, further endowed with the lure of fiction, shall initiate new beginnings to alternate (hi)stories and cityscapes. We shall attempt to describe the manifold experiences of the city.

CONTENT
Pursuing our rambling exploration on the lookout for urban environments beyond reasonable and more than ever considering humankind as embedded in, acting upon and dependent on its geological era, we shall look upon history’s intertwined layers and sediments as raw potential to be appropriated and composed with — joyfully disrespecting scientific authenticity. The visionary Histor seeks, finds novelty in the old, rather than an unfounded assertion of the present with the past. This semester aims at both finding and drafting fictional paths within erratic hyper-contexts (generated by hypothetical ruling incentives), and the obsessive recording of their past and present traces of erasures and becomings.

We will be collaborating with the Faculty of Game Design of the ZHdK in order to expand our discoveries and experience.

PROJECT
Driven by the choice of an Actor (who?), an Agent (how?) and a Timeframe (when?), Students will first conduct an objective survey focused on the observation and unprecedented reading of London, in order to map out and draft possible paths within the city (where?). Secondly, they will extrapolate multiple lines of fiction in a subjective survey focused on the experience within the city. Thirdly, the experience will be epistemized, idealized and intensified, in order to formulate a critical comment onto the contemporary condition and reveal future potentials. All contributions put together in a map of intensities shall display the striated and differentiated experience of the London metropolitan area. The city thus becomes the recording canvas of intertwined and proliferating storylines. Furthermore, students will construct an argumentative arsenal to support their discourse, based on the selective curation of evocative sources.

The complementary drawings, images and discourse crystallize the fictional metropolis’ shared desires and aspirations in an effort to rewrite alternate architectural and territorial fictions and reflect critically on contemporary conditions, overthrowing socio-economic status quo.

052-1147-22L
Architectural Design V-IX: Power to the people - Energy and Territory in the Rheinland (M.Topalovic)

Prerequisites / notice
Group work only.
Introduction: 20.9.22, 10 am (location to be announced)
Mid term crits: Dates to be announced
Final crits: 20./21.12.2022
Extra costs approx CHF 30.-- (besides the seminar week).

W 14 credits 16U M. Topalovic

Abstract
Who owns and controls the energy we use? During the semester we will explore the Rheinishe Revier to find out how energy production has formed this landscape in the past and present, and to learn from the precedents. Renewable energy has the potential to regenerate the social and the ecological fabric of territory. Can we imagine landscapes where energy is not a product, but a common good?

Objective
New Ecologies
New Ecologies is a studio series at Architecture of Territory dedicated to ecologising architecture. Ecological thinking, which foregrounds the interactions between organisms (or by extension between objects, or social and technical systems) and their environments, is applied in considering design practices in their social and environmental effects. The studio series is affiliated with the Future Cities Laboratory and the ETH EPFL Master of Advanced Studies MAS UTD. Citizens, experts, fellow designers and artists will accompany us in the process.

Process and results
The semester consists of investigative journeys and intensive studio sessions. Architecture of Territory values intellectual curiosity, commitment and team spirit. We are looking for avid travellers and team workers, motivated to make strong and independent contributions. Our approach enables students to work with a range of methods and sources pertaining to territory, including ethnographic fieldwork, literature research and essay writing, drawing techniques, videography, and online publishing. Experts and guests will help us on the journey. Students work in groups of two to three.

Seminar week
An investigative journey constitutes the core of the project. The seminar week will be dedicated to exploring the manifold facets of energy landscapes in the Rheinishe Revier. With our guides we will traverse the territory, visit mining pits, old and new forests and villages and speak with locals, experts, activists and pioneers of energy transition. The common days are followed by a period dedicated to fieldwork in respective student teams. The seminar week takes place from October 22–30 (cost frame B). It is integrated, mandatory, and open to all interested students.

Lecture series: My Energy
Within the lecture series running in alignment with the studio, four guest speakers engaged in fields ranging from energy humanities and feminist political ecology, to urban history and urban design, will approach the notions such as energy transition, decarbonisation, genealogy of energy, and urban microclimates.
Who owns and controls the energy we use? The energy crisis looming over Europe this fall as a consequence of the Ukraine war has made it clear that European geopolitics and power asymmetries have been built on fossil fuels. Yet the discussions around energy transition usually revolve around reducing carbon emissions through technofix solutions, without questioning the broader politics of energy. The promise of energy transition, that renewable energies could be decental, ecological and above all democratic systems, is rarely explored. To understand the potentials of such transition, we need to approach energy as a vital agent producing the territory. Does energy production have to lead to ecosystem devastation and enhance social inequity, or can it unlock opportunities for a different future? Can architects and territorial designers envision and design a more democratic, equitable and ecological energy landscape?

There is probably no better place to understand energy and its impact on human life and environment than the Rheinland. Between Cologne and Aachen, the region also known as Rheinisches Revier, is an agro-industrial flatland, scarred through decades of coal mining, stripped of natural diversity and speckled with energy infrastructures, both fossil and renewable. High voltage powerlines, power plants’ cooling towers, wind parks, huge bucket-wheel excavators, photovoltaic fields and biogas plants criss-cross the land and fill the horizon, creating an experience of a dehumanised territory. The need for energy, in particular coal, has massively altered this territory for already more than a century. Hambach, the region’s largest brown coal open-pit mine, has a surface area of 85 square kilometres—equal to the city of Zurich. The volume of earth excavated every year in that mine equals four times the volume of earth moved to build the Panama Canal.

The energy industry penetrates the ground and affects every aspect of life. Entire villages have been razed, heritage landscapes lost, communities resettled, primary forests cut, roads relocated and rivers rerouted. The single main actor in charge is the energy corporation RWE. It has been criticised as top-down and profit-driven by climate activists and networks of resistance, which have formed in the region to struggle for greater democratic transparency and an ecological agenda by means of peaceful demonstrations and occupations of hamlets and infrastructures. In 2018, 50,000 people came together to celebrate the rescue of the Hambacher Forst that was saved from the expansion of the mine with the means of persistent activist protests.

Germany’s intended “coal exit”—Kohleausstieg—until 2038, will transform the Rheinland once again as mining operations are phased out in favour of landscapes of renewable energy and recreation. There is a danger herein that renewable energy farms will simply replace coal-fired power plants, while maintaining the same imperatives of increasing profits, growth and energy consumption that have characterised the production of coal (Dawson, 2020). With this mindset, we may be able to reduce carbon emissions, but the accompanying crises of increasing social polarisation, resource exhaustion and biodiversity loss will persist. Can we use the current momentum of energy transition to envision a meaningful change?

During the semester we will explore the Rheinische Revier to find out how energy production—from coal and gas to solar, wind and hydro—has formed this landscape in the past and present, and to learn from the precedents. Renewable energy has the potential to regenerate the social and the ecological fabric of territory. Can we imagine landscapes where energy is not a product, but a common good? Power to the people!

The seminar week is at the core of the project. After dedicated field exploration, students will be asked to write their own project briefs and develop analysis and projects for energy landscape.

**Prerequisites / notice**

Planning as an integrated discipline is included in this course.

**Group work only.**

Introduction: 20 September 2022, 09:00 am, ONA G35
Intermediate crits: 23 November 2022
Final crits: 21 December 2022
Extra costs: Approx. CHF 50.-- per student.

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<tr>
<td>Abstract</td>
<td>The alpine landscape is changing at an accelerated pace. This development is contrasted by a rudimentary description of the space as a basis for current planning. Against this background, we argue for a comprehensive and fine-grained profiling of the Alps as a starting point for the design of new landscapes. This under the premise of creating maximum difference.</td>
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<tr>
<td>Objective</td>
<td>Independent thinking and acting</td>
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<tr>
<td>Content</td>
<td>Increased pressure on the alpine landscape</td>
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<tr>
<td>Blurred view</td>
<td>The alpine landscape is changing at an accelerated pace. Progressive urbanization as well as climate change are fundamentally transforming the sensitive structure. In the course of this development, the importance of the Alps will strongly increase with regard to a broader context, because the manifold existing resources (fresh air, water, biodiversity) arouse numerous desires. The conflicts of interest and use that already exist today are likely to become even more acute as a result.</td>
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<td>Rethinking the Alpine Space</td>
<td>Against this background, we plead for the most fine-grained and multi-layered coverage of the space as a starting point for further discussion. This approach is based on the insight that the characteristic feature of the alpine landscape has always been its pronounced small-scale character, whereby each valley community is characterized by specific peculiarities, primarily due to the landscape conditions. We want to trace this &quot;substrate of the landscape&quot; and place it at the beginning of further considerations. In doing so, we are concerned with the accelerated generation of difference. For in the Alpine region &quot;the other&quot; is omnipresent in the neighborhood and has both an identity-forming and a stabilizing effect on the existence of the diverse communities.</td>
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<tr>
<td>Profiling landscapes</td>
<td>During the semester we will look at alpine valleys on the basis of a concrete case. From this intensive reading of space, we derive specific uses for each spatial chamber, which will subsequently be further sharpened and visualized using design tools. The image of future alpine landscapes has a double meaning. It bundles the levels of use and perception into a synthesis, but it is also the iconographic version of a perspective on the way to profiling the Alps. At the same time, the image is always to regenerate the social and the ecological fabric of territory. Can we imagine landscapes where energy is not a product, but a common good? Power to the people!</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 99 of 2416
Lecture notes
The workbook will be handed out during the first week of the semester (20 CHF).

Literature
Relevant literature is included in the workbook.

Prerequisites / notice
Co-teaching: Günther Vogt & Thomas Kissling
Scientific Support: Markus Ritter & Rolf Weingartner
Assistants: Fabiana Frisullo, David Jung, Andreas Klein

Individual work and group work, whereof at least 5 weeks of group work.

Introduction: February 21, 2022, 9:00 a.m. (tbc), Place: Case Studio Vogt (Stampfenbachstrasse 59, 8006 Zurich);
Debates: tba
Intermediate reviews: tba
Final reviews: tba
Extra costs: approx. 150.- (seminar week excluded).

052-1151-22L Architectural Design V-IX: Topic (Student-led Teaching F. Persyn)
W 14 credits 16U F. Persyn

Abstract
To follow

Objective
To follow

Content
To follow

Prerequisites / notice
To follow

052-1181-22L Architectural Design V-IX: The Economy of the Project W I - Forms of living (Vertr. Kerez)
W 14 credits 16U F. Rossi, F. B. Gagliardi

Abstract
Architectural space is shaped from the dialogue between the world of facts and the world of ideas and one cannot exist without the presence of the other. The design studio starts from the belief that architecture is the expression of its time and that architects translate, through the medium of space, their own awareness of a specific way of living in a specific geographical context.

Objective
Task
Students will be asked to work in groups of two. Eighteen plots scattered all around the Swiss context will trigger eighteen forms of living for human dwellings that range from a house for one person to the scale of housing. Each group will develop their own design position that should have a strategic, an economical and a spatial strive that makes sense within the framework of the context and their vision of form of living.

The design strategy will be the result of the collision between the awareness of the context - as a set of categorical facts - together with the design intention. One will reinforce the other and the two will give form to architecture.

Tools
A reader, intended as a manual, will serve as a general guideline of how to extrapolate design criteria from context data. It will highlight the different clusters that shape our context in order to define possible starting points for analyzing and developing a design strategy.

The design process will develop by testing technological tools that enable the design of spaces in real time (VR). External support will be provided by the studio through the presence of Visual and Digital Artists.

The course will provide two series of lectures which will run in parallel. Invited guests will take a position from each side of the spectrum.
Architectural space is shaped from the dialogue between the world of facts and the world of ideas and one cannot exist without the presence of the other.

The design studio starts from the belief that architecture is the expression of its time and that architects translate, through the medium of space, their own awareness of a specific way of living in a specific geographical context.

Context is intended as a sum of scientific agents that form its being in a specific locus today. Architecture exists in the threshold between a scientific understanding of the context in which we operate and the phenomenological investigation of the forms of living we want to project on it. When both are translated into the design process, their encounter generates architecture.

Context is meant as the representation of the data inherent to the listed below clusters:

- Real Estate Context: the economical laws and systems that govern the market;
- Normative Context: the series of regulations that frame our interventions;
- Environmental Context: the natural agents that exist;
- Matter Context: the physical substance that molds our spaces;
- Theoretical Context: expressions of forms of living.

The consciousness and acquaintance of this data embedded and instrumentalized as part of the design process gives rise to the economy of the project. Each of them will be treated in an analytical way and processed through tools that are able to put into evidence their meaning in order to extrapolate criteria for design strategies.

The Governance of the economy of the project through Technology, at the service of Architecture, drives efficiency and precision, raising continuous awareness across the design process.

In parallel to this knowledge-based research, the design studio will focus on the phenomenological ideas of possible forms of living. A strategy will be then formulated and translated in space, defining variations of the living form, rooted in the interpretation and awareness of the context.

The goal is to develop forms of living that are a manifestation of our time, a new trajectory of experiencing space rather than the result of predetermined conventions inherited from the past.

Objective

- Grundlegendes Wissen im Landschaftsarchitektur
- Entwicklung einer Haltung, Formulierung einer Hypothese
- Wahl entsprechender Entwurfsselemente
- Entwurf und Darstellung komplexer/dynamischer Systeme und Landschaftsräumen
- grossmasstäbliches Entwerfen
- Alternieren zwischen verschiedenen Messstäben

Content


Aktuell steht der Raum vor neuen Herausforderungen: So setzt die Frage nach Energie und Wasser diese regenreichste Region der Schweiz erneut in den Fokus als Speicher, gleichzeitig wird über eine Unterschutzstellung der Eisenbahnstrecke als Weltkulturerbe diskutiert. Allem voran aber steigt aufgrund der zunehmenden Wetterextreme die Gefahr von Murgängen oder Steinschlägen. All diese divergierenden Fragestellungen, zwischen Schutz und Innovation / zwischen Transit und Speicher, fordern nach klugen und vielschichtigen Antworten für diese verdichtete Landschaft.

Mit dem Bau der zweiten Röhre des Autobahntunnels wird erneut eine Infrastrukturebene reingelegt. Der Bau generiert 7.4 Mio Tonnen Aushubmaterial und belastet die Täler für die kommenden 7 Jahre. Wir nehmen diesen Prozess als Anlass, über zukünftige Rolle und Gestalt des Gotthards nachzudenken und über unserem Umgang mit dem kulturellen Erbe zu diskutieren.

Auf der Suche nach einer möglichen neuen Identität dieses Raumes werden die Studierenden gebeten, eine eigene Haltung einzunehmen und ihre Vision zu entwickeln. Im Rahmen des Semesters wollen wir den Pioniergeist der vergangenen Tage aufleben lassen und stellen den Studierenden die Frage nach ihrem eigenen, zukünftigen Mythos. Zusätzliche integrierte Disziplin: Landschaft und Urbane Studien (LUS)

Einführungsveranstaltung: 20. September 2022, 09:00 am, Rote Hölle
Zwischenkritiken: 11.10/23.11.2022
Final crits 20.12/21.12.2022
Extra costs: Approx. CHF 50.-- per student.

Prerequisites / notice


Project grading at semester end is based on the list of enrolments on 1.11.22, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

052-1201-22L Preparation Semester Free Master Thesis HS22 W 14 credits 16A Lecturers

Preparation semester for a self-determined Master thesis within the Department of Architecture, of ETH Zurich.

Self-dependent development of a program, according to which one intends to realize a free master thesis in the following semester.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php).

For more information, please visit: https://www.studservice.ethz.ch/
The objective is that the students engage in a debate of a differentiated functional planning as a basis for complex buildings which are to be

Abstract
We are used to designing architecture from a supposedly objective perspective. With immersive technologies, we overcome this distance, expand our perception and dive directly into the space to be designed. In doing so, we develop an altered understanding of space, in which we digitally design architecture and its construction and simultaneously move within it.

Objective
In the "Immersive Studio" we will get to know contemporary digital design methods and apply them in a creative, sensitive and meaningful way in our architectural designs. We will critically reflect the potentials of these technologies beyond a pure efficiency thinking and develop an independent, mature and emancipated attitude towards them.

We will achieve this by consistently developing our designs on the digital 3D model. We will generate and edit this both by manual modeling and, where useful and interesting, algorithmically and parametrically. We will regularly walk through the designs in virtual space, analyze them spatially and discuss them.

Despite the intensive and extensive use of digital methods, the architectural design, its materialization and fabrication as well as sustainability will be at the center of our investigation.

Content

Im Immersiven Studio werden wir zeitgemäße digitale Entwurfsmethoden kennenlernen und sie auf kreative, sensible und sinnvolle Art einsetzen. Wir werden die Potenziale dieser Technologien jenseits eines reinen Effizienzdenkens kritisch reflektieren und ihnen gegenüber eine eigenständige und emanzipierte Haltung entwickeln.

Dies erreichen wir, indem wir unsere Entwürfe konsequent am digitalen 3D-Modell entwickeln. Wir werden dieses sowohl durch manuelles Modellieren als auch, wo sinnvoll und interessant, algorithmisch und parametrisch generieren und bearbeiten. Die Entwürfe werden wir regelmäßig im virtuellen Raum begehen, räumlich überprüfen und diskutieren.

Aspekte der Materialisierung, der Fabrikation und der Nachhaltigkeit werden die Diskussion um den architektonischen Entwurf massgebend prägen.


Programmatisch werden wir versuchen, folgende Frage zu beantworten: Welche räumlichen Anforderungen stellen immersive Studios wie unseres an eine künftige Architekturschule, wie sieht der Zeichensaal des digitalen Zeitalters aus und wie lassen sich temporäre Wohnformen mit dem Programm einer Architekturschule verknüpfen?


Prerequisites / notice
Individual work and group work (whereof 5 or more weeks of group work.

Introduction: 20.9.22, 10:00 h (HIT F22);
Concept discussion: 19.10.;
Intermediate discussion: 23.11.;
Presentation discussion: 8.12.;
Extra costs: CHF 100.-- (seminar week not included)

Electives and Focus Works

Electives

Design and Architecture

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
052-0511-22L | Planning Strategies for Complex Buildings Using the Example of Health Facilities | W | 2 credits | 2V | T. Guthknecht

Abstract
Independently written scientific paper concerning a subject of planning of complex buildings - such as health facility planning and design - with special focus upon the dynamic changes in this context and the related planning and building reactions to them.

Objective
The objective is that the students engage in a debate of a differentiated functional planning as a basis for complex buildings which are to be successful functionally, operationally and in design.

On the basis of a given scope of themes the students carry out research aiming for possible improvements for example in health facility planning. The scope of subjects is announced at the beginning of each semester.

Content
Complex buildings such as health care buildings are subject to constant change. In a new hospital building 60% of the diagnostic and treatment areas are subject to building changes within the first 10 years of operation. Architecture has to develop concepts which accommodate this level of dynamics into the building structure in a better way.

In the coming years this need for adaptability is going to be challenges even further by the even more reducing health care resources. The sustainability will be at the center of our investigation.

Lecture notes
Presentations of the lecturer and guests will be made available

052-0521-22L | 3D Scanning and Freeform Modeling | W | 2 credits | 2U | A. Grüninger

Enrolment in agreement with the lecturer only (grueninger@arch.ethz.ch).
Is not offered after HS22.

Abstract
Design in virtual space - hybrid World!
Monday 14 to 16 Uhr
In the newly designed elective, we will dive into the hybrid VR world. You will learn the basics in the first elective days for Photogrammetry, Twin Motion, Game Engine Unity, Youtube 360 and Gravety Sketch.

After these first elective days, we will dive into project work where your idea & vision realized in the virtual world. How do you combine the different techniques to create a product, design in architecture or art.

The Chair of Architecture & Art at ETH Zurich, Department of Architecture thinks and realizes in basic research since 2012 in the topic of new media in architecture. The research journey went over person scans, high resolution 3D scans as certificates of authenticity for art rental to spatial Lidar scans in punk clouds. Since 2016, there is the possibility of VR technology. To experience virtual worlds with VR glasses. The knowledge from scan, texture and feedback from scan to CAD allows us to experiment with VR glasses. We from the research of the Department of Architecture and Art are looking at issues such as space and time, the dimensions and gravity in a metaVers, metavers, the synonym for virtual worlds. Further, we consider how the handling of VR glasses takes place in terms of the consumer. How are the VR goggles used, donned or held in the different applications.

Please send us a letter of motivation as to what your aspirations, goals / desires are for this elective.
grueninger@arch.ethz.ch; kiryk@arch.ethz.ch

Tools where we use:
Gravity Sketch
Reality Capture (3D scan program)
Unity
TwinMotion
Oculus Quest 2
USB for Oculus Link (Beta Oculus Air)

These are the tools we will use and learn as we journey together "Designing in Virtual Space".

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Tools where we use:
Gravity Sketch
Reality Capture (3D scan program)
Unity
TwinMotion
Oculus Quest 2
USB for Oculus Link (Beta Oculus Air)

These are the tools we will use and learn as we journey together "Designing in Virtual Space".

052-0523-22L 360° - Reality to Virtuality W 2 credits 2G to be announced

Abstract
Design in virtual space - 360° Reality to Virtuality (052-0523-00L) meets 3D Scanning & Modelling (052-0521-00L)

Objective
The goal is to 3D-scan an existing space and use it in VR as a context for further design. First, we learn the tools; then we work on an architectural VR-project; at the end of the course, we present the works in our exhibition space in HIL F.

Every student gets Oculus Quest VR-Headset to work with at home during the semester.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 103 of 2416
We focus on virtual reality design process and create our own spaces using VR-headsets. We hope that this new technologies will change the design of architecture in the near future and will influence the learning process at ETH as well. The goal is to 3D-scan an existing space and use it in VR as a context for further design. First, we learn the tools; then we work on an architectural VR-project; at the end of the course, we present the works in our exhibition space in HIL F.

Every Student gets Oculus Quest VR-Headset to work with at home during the semester.

In case of loss or damage that is uncovered by the warranty the student has to cover the equipment cost 510chf (minus 200chf deposit). If you already have Oculus Quest (Model 1 or 2) you don’t need to pay any deposit and you can work on your own device.

**Prerequisites / notice**

Course requirements:
Both courses are connected “360 – Reality to Virtuality“ and “3D-Modeling”
Please register for both courses: “360 – Reality to Virtuality” (052-0523-00L) and “3D-Modeling” (052-0521-00L) (2x 2 ECTS)
Classroom-teaching (online or physical meetings, Mondays, 14:00 – 16:00)
Self-teaching, research etc. (Mondays 12:00 – 14:00, or whenever you have time)

Please send us your short letter of motivation to Nicolas Rolle: rolle@arch.ethz.ch

**Tools:**
- Gravity Sketch
- Photogrammetry 3D-scanning (Reality Capture)
- Oculus Quest 2
- Oculus Link (USB-C cable)

**052-0533-22L New Focal Points of Construction: Masonry**

**W 2 credits 2G I. von Meiss-Leuthold, D. Mettler, D. Studer**

**Objective**
- Target of the course is the understanding of the impacts of material, technology and construction to the architectural education of the students.
- Development of individual expression in the realm of drawing; artistic flexibility and skill in the areas of working strategy and aesthetic development of corresponding methods in design.

**Abstract**
The elective subject “New focal points of construction” investigates the complex interaction of construction elements in masonry by means of exemplary architectonic tender points such as base, wall, chamber, roof etc. The comparative analysis of built constructions serves as a basis for further development of future constructions.

**Content**
1. Introduction of current level of technique, typical methods, and set of problems in masonry
2. Colloquium with guests of producing and processing companies.
3. Visit of construction site and factory

**Excercise:**
- Analysis and presentation in group of two of a building.

**Prerequisites / notice**

https://www.buk.arch.ethz.ch/Lehre/NKOHS2022

**052-0535-22L Model and Design**

**W 3 credits 4U A. Tellini, C. Egli**

**Objective**
The primary pursuit is an in-depth study of three-dimensional form, color, material and composition along with the practical development of your own technical and artistic competences.

**Abstract**
The course Model and Design teaches architectural model building in an explorative way through systematic experiments and the development of corresponding methods in design.

**Content**
- In the first part of the semester, we are going to explore a variety of materials and techniques, both typical and atypical for the architectural model building. Equipped with the knowledge gained during the first phase we'll go ahead and try to put all of that experience into use during the final build. With this final build, we reflect on basic design topics like the initial intent, color, material, composition, and construction in order to understand the sensual role of the model considering its sculptural properties.

**Prerequisites / notice**

In addition, a processing time during the week of about 4 hours can be expected.

**052-0537-22L Free Drawing**

**W 2 credits 2V H. E. Franzen**

**Objective**
- Drawing is used to ascertain and develop the artistic ideas and abilities of students. Different techniques and methods will be tested.
- Development of individual expression in the realm of drawing; artistic flexibility and skill in the areas of working strategy and aesthetic impact.

**Content**
- Development of individual expression in the realm of drawing; artistic flexibility and skill in the areas of working strategy and aesthetic impact.

**Prerequisites / notice**

The number of participants is unlimited.

**052-0549-22L Hybrid Modeling: 3D-Printing for the Architectural Design**

**W 2 credits 2S J. Benhamu Esayag**

**Objective**
- The HYTAC Elective Course offers the opportunity to explore alternative ways to approach Context Analysis. The students will learn the basic principles and workflows behind photogrammetry, 3d-modeling and 3D-printing, to produce digital and physical (3d-printed) models using drone footage.


- By the end of this course, the students will be capable of:
  a) flying a drone
  b) creating and processing point-cloud-generated context models
  c) producing 3D-printed site-models in architectural scale
  d) using the above digital tools to advance their personal design workflows.
The goal of the course is to introduce digital technologies and facilitate common architectural workflows by skipping the time-consuming processes of 3D context modeling.

The course includes:
- Introduction to photogrammetry and 3D printing through lectures and tutorials.
- Flight-Days: students will get the possibility to fly a drone (DJI Mavic 2 Zoom) at the site of interest.
- Generation of a digital twin of the selected site through photogrammetry and production of a physical model (3D printed)
- Use of CAD software like Rhino, Blender and ArchiCAD. Basic skills can be acquired during the course.
- A small design challenge using the newly learned skills.

In case of questions regarding the course, please visit our website: https://hytac.arch.ethz.ch/courses/elective-2/ or contact us directly via email (hytac@arch.ethz.ch).

Literature
www.3djony.com

Basic Knowledge of 3D printing technology is required.
Objective
The examination of filmic space situations and performance discloses new perceptions of architecture which will be studied on behalf of film analyses and experimental topics. During the course the course space-effective creative means such as editing or framing will be introduced and discussed under perspective aspects. Mediational within spatial perception can thus be integrated into a development of cultural history and leads towards a conception which goes beyond the limits of architecture and stimulates new processes of design.

Content
New perceptions of architecture are studied on behalf of film analyses and experimental topics. During the course space-effective creative means such as editing or framing will be introduced and discussed under perspective aspects. Mediational within spatial perception can thus be integrated into a development of cultural history and leads towards a conception which goes beyond the limits of architecture and stimulates new processes of design.

052-0557-22L
BUK Construction Lab
Places are limited. Before registering you need the acceptance of the lecturers!

Abstract
Using innovative materials, the students are shown the integral relationship between the construction process, planning and execution. With a focus on the interaction of conception and implementation, constructions and details for novel materials are developed and the field test is planned in self-made case studies. For this purpose, we will focus on the self compacting earth material by Oxaar.

Objective
Understand the complex relationships between material, detail and built artifact. New artistic methods are designed, analyzed and applied from a deeper understanding of innovative building materials.

Content
Phase 1: The analysis of innovative building materials aims at their application in construction thanks to experimental construction methods.
Phase 2: Derived, independent drafts (group work) for case studies are developed from the newly conceived construction methods. During the semester the students gradually approach the real scale and check the interactions on the construction concept.
Phase 3: The focus is on realization. A suitable project is selected from the second phase and further developed together. The detailed planning questions the previous decisions. Finally, the construction is materialized and checked by building case study 1/1.

During the semester, the students are accompanied by specialists with lectures, tours and reviews.

Prerequisites / notice
Places are limited and visiting the introductory lecture is mandatory.

052-0555-22L
Formalistic Analysis of the Architecture of the Neo-Liberal Ideology: Examples of Zurich
This course is offered until end of HS22.

Abstract
Using built examples, the elective examines the architecture that produces the neoliberal ideology. Based on the method of historical building surveys, the formal-architectural properties are described, analyzed and finally summarized in the sense of a formal catalog of neoliberal architecture.

Objective
The participants critically deal with contemporary urban and building production from a design perspective. By applying the method of the course, they learn the ability to describe and analyze the formal-architectural properties of architecture.

Content
The examples of Europaplatz, Richti-Areal and Campus Hönggerberg worked on in the past three semesters were each touted as fulfilling the highest demands that can currently be placed on architecture and planning. In close cooperation with the authorities, the various owners realized projects that exemplify in the Swiss context what ‘good planning’ and ‘good politics’ are with regard to the development of urban planning and architecture.

Instead of comprehending the complex process of these examples and accepting the built as a consequence, the elective turns the analysis ‘head on its feet’; what kind of architecture has been realised? If objects can not lie (cf. Büile, Heinrich: Handbuch der Archäologie, Munich 1913), the ideology of the planning process can also be read from the architecture itself - provided that it is questioned methodically and precisely.

By the means of a formalistic analysis, which is based on the scientific method of historical building surveys, the three examples were examined for their formal-architectural qualities. The theses on neoliberal architecture, which have been collectively formulated in the course of this work, will be examined in the fourth and final implementation of the course.

The theses will be tested by means of a formal-architectural analysis on Zurich examples to be chosen by the students themselves, in order to revise or reject them in a second step, if necessary. In a final step, the results from the analysis will be summarized in the sense of a formal catalog of neoliberal architecture.

Fostered competencies
Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Analytical Competencies
Social Competencies: Communication
Personal Competencies: Integrity and Work Ethics

Self-direction and Self-management

History and Theory of Architecture

Number
Title
Type
ECTS
Hours
Lecturers

052-0813-22L
History, Criticism and Theory in Architecture: Mental Mapping and Mapping the Mind
W
2 credits
2S
L. Stalder, M. Kaijima

Abstract
What is the relationship between mental maps, plans and places? On the one hand, the built environment can be represented as a map, an instrument that helps us orient in space but also changes our mental image of it. On the other hand, maps allow us to represent mental states. In this reading seminar, we explore how maps mediate the relationship between the built environment and the self.

Objective
We will examine different aspects related to mapping, such as the effects of the built environment on emotions and behaviour in psychogeography, the mental representation of space in cognitive mapping, the impact of physical and mental restrictions on the perception of space, and the representation of these perceptions through drawings such as those used in psychological assessment and therapy. By focussing on maps and their relation to mental states, the course addresses spatial issues in psychiatric theory and practice.

Content
Together we will trace the history of mapping as a cultural technique and the use of drawings as a tool for translating the properties of space. We will examine different aspects related to mapping, such as the effects of the built environment on emotions and behaviour in psychogeography, the mental representation of space in cognitive mapping, the impact of physical and mental restrictions on the perception of space, and the representation of these perceptions through drawings such as those used in psychological assessment and therapy. By focussing on maps and their relation to mental states, the course addresses spatial issues in psychiatric theory and practice.

Prerequisites / notice
This course is intended as a preparation for a seminar week in Paris which will be led by Professors Momoyo Kaijima and Laurent Stalder in the Spring of 2023. Students looking to join this study trip are strongly advised to take this course. As the number of participating students is limited to 25, Master’s students will be given priority.

The course is jointly offered by the Chair for the Theory of Architecture and the Chair of Architectural Behaviorology and will feature inputs from experts from several disciplines.
This seminar explores resistance to the post-1945 (1957-1980) globalisation of architectural techniques, which can be found in media used to communicate alternatives. Inspired by practices documented in the dispersed grey literature from the "global South" from 1957-1980, we will experiment with the alternative, independent productions of our own manuals about autonomous ways of building.

Through this process we will realise our own alternative creative agency as an asset that we could bring to other situations where we need to act autonomously. The case studies it will explore, which are not well known beyond local circulation, will support us to devise and communicate ways to create architecture without easy recourse to new materials, exotic technologies, foreign exchange, or the advice of outsiders.

The ecological imperative forces architects to re-unite their design with sustainable construction. But architecture criticism also has to find new criteria in order to place buildings in light of their environment. Context-related aspects could be deduced from site visit. To this day, crimes are committed in the name of architecture. Therefore global trade chains and economic sectors that dominate the entire construction process will also be examined in this seminar – and participants are expected to have the courage to carry out investigative research.

The weekly schedule is published at the beginning of the semester and is included in the reader.
How do we talk and write about food? What are criteria for good food? How does it relate to history, memory, money? In which spaces is food being produced? What do we eat and how do we tell the story of the food? The group will discuss it and talk about taste, aspect, quality, associations.

In this seminar, we will eat and speak about home-made food, discuss with invited guests and read texts from the fields of history, theory, poetry and fiction. We will read and discuss texts from the fields of history, theory, poetry and fiction.

The City Lived: ‘Sites-and-Services’

This be-weekly course is taught in 2 groups of max. 15 students each, in English and German.

Course dates s. room reservations!
Group 1: Thursdays 16:00 - 20:00; Group 2: Fridays 14:00 - 18:00

Students will be selected on the basis of a motivation letter.
Deadline: 09.09.2022, 12:00 h, to wootton@arch.ethz.ch.
Please also state a preference which day suit you best:
Group 1: Thursday evening
Group 2: Friday afternoon

Course dates s. room reservations!
Students will be selected on the basis of a motivation letter.
Deadline: 16.9.22, 12:00 h, to wootton@arch.ethz.ch.
The course will be graded as follows:

Active participation in the course: 20%
Active participation in the course involves the capacity of asking mature questions in response to lectures, critically discussing required readings during our discussion seminars and giving constructive feedback to fellow students during presentations.

Mid-term assignment: 30%
In small teams, students will present a collective presentation on one particular sites-and-services project, each outlining an individual research question they would like to focus on in the remainder of the semester.

Final assignment: 50%
The final assignment consists of two components: (1) an in-class presentation where in small teams students will present both a collective and individual presentation on one particular sites-and-services project; (2) a short individual written paper, pursuing a research question that reflects the individual student's interest in the topic.

Fostered competencies

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052-0829-22L History of Art and Architecture: Special Topics

Does not take place this semester.
Not eligible as a Compulsory GESS Elective for students of D-ARCH.

Abstract
Architecture Exhibitions
To exhibit architecture is an oxymoron. In architecture we need many tools to communicate a project to an audience. These evidences of architectural thought are used to "exhibit the architecture." Images, words and representations transmit ideas, concepts and ideologies and create shared meaning of things, which we will analyze and discuss.

Objective
See course description

Content
Architecture Exhibitions
To exhibit architecture is an oxymoron. In architecture we need sketches, drawings, models, plans, scribbles, videos, interviews, and renderings to communicate a project to an audience before and even after it is built. These evidences of architectural thought are used to "exhibit the architecture." Images, words and representations transmit ideas, concepts and ideologies and create shared meaning of things, which we will analyze and discuss. The object is to provide an imaginative space for the students to examine methods and relations between discourse and medium, context and institutional frameworks that inform representations of architecture in historical and contemporary practices.

052-0833-22L PhD Teaching

Does not take place this semester.

Abstract
The course discusses the material encounter of modern architecture and photojournalism as both converged to transform Brasília, the new capital of Brazil designed by Costa and Niemeyer, into a global mass media event. The photographic material produced for magazines promoted images of a new imaginary nation and staged dissonances and microhistories of this massive urban-architectural endeavor.

Objective
To understand the construction process of modern architecture’s photographic representation in international mass media through the collaboration network between photojournalists, editors, illustrated magazines, photo agencies and new technologies.
To explore how photojournalism challenges the sterile photographic depiction of modern architecture’s spaces. Instead of abstract conditions and no people, photojournalistic images perform a sort of ‘offstage’, introducing the construction site, everyday events, temporary settlements, imperfections, materials, maintenance, impacts on landscapes and communities.
To investigate the exploitative nature and colonial gaze of “humanitarian” photojournalism, and the search for the exotic in faraway lands.
Can we achieve gender parity in architectural historiography? This course is intended to give students an insight into writing critical histories of architecture, challenging and expanding canons. Based on reading seminars and writing exercises, sessions will focus on questions of gender and parity in architecture while exploring specific case studies from the 18th and 19th centuries.

In this course, we will explore what forms of agency woman had before 1900, focusing on her pen as her main tool. Writing and publishing allowed women a public voice long before she was allowed to enrol for professional degrees or have the vote at the ballot box. She was not silent, and she had a lot to say about her environment. Her lived experiences and her skill to ascribe meaning to spaces for others to relive is as crucial to our understanding of architectural history as that of contemporaneous design practices. We must listen to her if we want to come closer to parity in architectural histories. This course will broaden students' understanding of the modern age by challenging existing canons in terms of gender, class, race, and other social categorisations creating systems of oppression.

Consisting of reading seminars and writing exercises, we will engage both with 18th and 19th-century primary sources as well as feminist theory across the last 300 years, embedding these in the wider contexts to achieve parity. Writing is central to the course, both as primary source as well as a tool to develop our own engagement with architecture and its histories. Students will gain skills in historical research as well as with digital humanities tools. Concepts taught include situated writing, intensive/extensive reading as well as text mining and analysis. Students will be enabled to write their own histories, to take agency themselves in which ways they want to know about the past.

Assignments will consist of several written pieces, produced during the semester, of differing length and format, both creative and critical. Students will gain skills in historical research as well as with digital humanities tools. Concepts taught include situated writing, intensive/extensive reading as well as text mining and analysis. Students will be enabled to write their own histories, to take agency themselves in which ways they want to know about the past.

This course is intended for students from the 5th semester onwards. Attendance is a key requirement.
Abstract
The subject of this seminar is the relationship between architecture and social class.

Objective
The participants gain familiarity with the analysis terms of historical cultural sociology and can apply them to questions of architecture and urban research.

Content
Class matters – in architecture, art and design

The subject of this seminar is the relationship between architecture and social class.

Our inherited class reference determines our social architecture: how we relate to each other in a historically grown, hierarchically structured space, how we perceive the built world, how we intervene in it in a creative way and how we judge sensuality and beauty, all of this is strongly pre-structured and yet leaves nothing to be desired levee open. We can’t help what class we’re born into, but we can understand, mediate—and maybe even change—the social reflexes and unconscious beliefs that arise out of this coincidence. This seminar offers a sociological, historical and aesthetic basis for this.

- On the basis of theoretical texts, a number of questions are discussed: How is the racialization of the working class manifested in the history of cultural production? How are economic discrimination and privilege in the field of the arts related to normative gender categories? How do we make the big analytic terms our own when we write about class and architecture to connect with others?
- Exercises on graphical representations of social strata. What is a spatial perspective considering the creativity of class habits? How can we present the fragments of our perception, determined by class origin, as a whole without leveling or even condemning individual positions? How do we deal with the naturalized power of imagery’s common sense when representing class issues in architecture?
- Personal engagement with autobiographical photo material regarding the manifestation of the habitual, inherited lifestyle of a certain milieu or a certain class faction - or regarding the manifestation of the break with this heritage. Approaching the answer to the question: What makes the difference – or, how do I make the difference - between a narcissistic and an objectified architectural view of social space?

052-0845-22L Reflection on Exhibition and Art Practice Now

W 2 credits 2U P. Ursprung

This course is limited to 20 participants. This course poses the question of how projects of land, terrain, and territory enfold laboring bodies and gather around, legislate, and flow as these formations, and their knowledge systems, shaped and sustained over the last 500 years by the spatial grammar of colonization—the “rifts of broken earths” created by modernization’s damaged ecologies, we will trace the ways in which those spatial orders have been disrupted and re-imagined, proposing new methodologies for the design of planetary futures.

- Does not take place this semester.
- Enrollment on agreement with the lecturer (s. course description)
- Students gain knowledge of the concept of “Artistic Research” and learn to distinguish it from other artistic strategies. They will get an overview of the latest discourse by reading the most important theories and discussing them together in the seminar. Moreover, they will become acquainted with different approaches and techniques of “Artistic Research” in personal encounters with artists.
- For some time now, the term “Artistic Research” is on everyone’s lips. Has it turned into a buzzword for a phenomenon that has – in fact – been in existence for centuries? Or does the term describe a new approach which has come into existence since the 1990s only? While looking back into history, the seminar will deal with the question how artistic research can be defined in the 21st century and how it differs from the notion of the universal artist so common during Renaissance. Students will read and discuss texts (for example from Hans-Jörg Rheinberger, Elke Bippus or Dieter Mersch) and dispute the phenomenon theoretically. Besides, they will engage in conversation with artists, who are doing “Artistic Research”. They will particularly discuss the challenges and chances of artists and scientists, whenever they embark on the context of the other one.

052-0851-22L Topical Questions in History and Theory of Architecture: (Un)settling Territory

W 2 credits 2S H. A. Kennedy, T. Avermaete

This course poses the question of how projects of land, terrain, and territory enfold laboring bodies and gather around, legislate, and flow through settlement. Linking the architectures of colonization to modernization’s damaged ecologies, we will trace the ways in which those spatial orders have been disrupted and re-imagined, proposing new methodologies for the design of planetary futures.

- Seeking to unearth longstanding entanglements between land and architecture, we will chart the imperial global geographies, the territorial formations, and their knowledge systems, shaped and sustained over the last 500 years by the spatial grammar of colonization—the “rifts of broken earths” created by modernization’s displacements. These formations share a common heritage of practices informed by the same recurring themes that define the damaged ecologies of the Anthropocene, a subject of increasing decolonial scrutiny within studies of the built and landscaped environment. Those themes include entrenched forms of racialized violence, land alienation, environmental degradation, and large-scale species loss, narratives of modernity archived by the land and landscape. Thinking alongside Kathryn Yusoff and Swati Chattopadhyay and engaging Indigenous spatial ontologies and Black feminist- and postcolonial counter-mapping, we will trace the ways in which those territorial orders have been disrupted, unsettled, and re-imagined, proposing new methodologies for the design of planetary futures.

- This course opens with the hypothesis that the historical dynamic of deterrioralization that is fundamental to imperial and colonial structures—the unit of the global, formed by empire and capitalism—has taken shape through design and architectural interventions, stressing the need to better understand modern architecture’s land histories. Postcolonial theory further underscores the necessity to shift how we read design’s participation in capitalist transformations of the environment, its long history of “development thinking.” Thinking within and across differences, the readings for this course share a core set of decolonial practices, new patterns of thought, to chart the spatial histories of these transformations. Working with an interdisciplinary and intersectional approach and privileging marginalized voices and geographies, we will explore these interventions and developments with perspectives offered by recent movements in Black studies, critical feminist geography, Indigenous environmental history, and multispecies studies. Engaging these perspectives serves to shift how we understand who and what has shaped the architectural past, while unearthing long-standing but overlooked entanglements between land and the built environment.

- This course is aimed at students from the 5th semester onwards. It will require a set amount of reading and sessions will include intensive discussion and in-class exercises, so consistent attendance is very important.
We expect that students pursue their examination of the design process independently and in an original manner or that they develop a related theme from the perspective of the history of art and architecture. The work should be part of the design process and interact with it formally and in regard to content.

The aim of this seminar is to enable students to better understand social, political and/or historic dimensions of spatial aspects in their architectural designs. The students’ tasks include reflexive and analytical writing, the presentation and discussion of these reflections, literature research and the production of a final text, in which they summarize their most important findings and define a theoretical position that could guide their future work as designers.

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Method-specific Competencies**
- Professional, creative practice
- Problem-solving
- Media and digital technologies
- Leadership
- Evaluation

**Social Competencies**
- Self-direction and self-management
- Integrity and work ethics
- Sensitivity to diversity
- Negotiation
- Adaptability and flexibility
- Creative thinking
- Critical thinking
- Self-awareness and self-reflection

**Personal Competencies**
- Self-direction and self-management
- Integrity and work ethics
- Sensitivity to diversity
- Negotiation
- Adaptability and flexibility
- Creative thinking
- Critical thinking
- Self-awareness and self-reflection

**Fostered competencies**
- Self-direction and self-management
- Integrity and work ethics
- Sensitivity to diversity
- Negotiation
- Creativity
- Critical thinking
- Self-awareness

**052-0853-22L**
**Architecture Beyond the Studio: Reflecting the Social Dimension of Design**

This course is offered until end of spring 2023 semester.

**Abstract**

“Architecture beyond the studio” is a seminar with the aim to reflect and rethink the formal and spatial aspects of the students’ own design projects from the perspective of the Humanities and Social Sciences (HSS). Literature from the HSS is researched individually, related to the design projects in the form of a paper and presented jointly in an exhibition.

**Objective**

In this seminar students learn to critically reflect their practice as architects from the perspective of the humanities and social sciences (HSS). As object for these reflections serves one of the students’ own design projects. This can be an architectural project they have designed at a chair for architecture and design, an architectural practice or independently.

The main focus of the seminar lies on identifying a spatially and architecturally clearly defined aspect within the students’ design projects and in reflecting as well as deepening one’s own understanding of this aspect. By writing texts alienating architectural plans and images of their design projects and establishing an individual collection of architectural examples, the students learn to relate their own design practice to research of the HSS as well as to the built environment.

At the end of the semester, the students will be able to identify the historical, political sociological and/or economic dimensions of the architectural aspects in their design project as well as to locate these aspects in a contemporary architectural and HSS discourse. Furthermore, they learn to develop an individual conceptual position towards architectural-spatial questions and to communicate them visually and verbally.

**Content**

Currently, the discipline of architecture is undergoing substantial change. Political and social aspects are again becoming more important within the profession of architecture. In the 1980s and 1990s architects legitimized their designs by recurring to their artistic abilities and individual ingenuity. Today, however, practicing architects cannot escape the social and political responsibility that comes with the design of architectural buildings. An increasing number of public as well as private developers expect architects to include considerations about the social and cultural life of prospective inhabitants in their architectural designs.

Against this background, the seminar “Architecture beyond the Studio” bridges the gap between architectural design and the Humanities and Social Sciences (HSS). Supported by two lecturers – with backgrounds in architecture and the social sciences – the students develop texts in which they critically reflect on spatial aspects in one of their own design projects from the perspective of the HSS.

The aim of this seminar is to enable students to better understand social, political and/or historic dimensions of spatial aspects in their architectural designs. The students’ tasks include reflexive and analytical writing, the presentation and discussion of these reflections, literature research and the production of a final text, in which they summarize their most important findings and define a theoretical position that could guide their future work as designers.
Summer School: Tentacular Writing - A Peer-to-Peer Writing Retreat (ETH-EPFL)
For MSc ARCH students and Doctoral students.

Abstract
The summer school intends to renegotiate and experiment with the ways we – as researchers and spatial practitioners – perform writing, as a form and as a practice. In the set-up of a collective retreat in the Swiss Alps, in a non-hierarchical learning format, a group of peers is invited to shape an academic community, work alongside and discuss their work-in-progress informally.

Objective
The summer school aspires to establish a peer group of early-career scholars that stay connected beyond the summer school. By the end of the workshop, the participants will have:
- acquired skills on new writing methods
- discussed learning and writing outcomes collectively
- gained the opportunity to take the role of an editor of their colleagues work
- gained experience in presenting their work-in-progress in an informal setting

Content
The summer school explores a form of inhabitation that is neither touristic nor individual and allows for reflection and redefinition of what it means to retreat: We want to see retreating not as isolating and detouching but rather as engaging with localities and situating ourselves.

The summer school is articulated through the synthesis of three different formats:
- workshops organized by external guests offering inputs to the participant
- individual writing sessions for the participants to develop their material
- collective peer-to-peer discussion aiming at exchange and the formation of a peer-group

Writing Workshops
Room and Field, Writing One with Another: a Site-Writing Workshop with Jane Rendell and Polly Gould
Exploring Sensorial Practices
Writing with sound, by Ludwig Berger, sound artist
Follow your nose, by Curdin Tones, community-artist
With Collective Cooking Sessions and Fountain Bathing curated by the community-artist Curdin Tones

Place: The summer is organized at the Alpine village of Tschlin in Graubünden, Switzerland. Participants will be hosted at three local houses. Common workshops will be organized at the venue of the local school and at the artistic residency space of Somalgors74. The summer school explores a form of inhabitation that is neither touristic nor individual and allows for reflection and redefinition of what it means to retreat: We want to see retreating not as isolating and detouching but rather as engaging with localities and situating ourselves.

Date: The summer school will take place on 11 – 16 September 2022.

Organisers
Metaxia Markaki (ETHZ), Johanna Just (ETHZ), Sila Karatas (EPFL)
Prerequisites / notice
Participation fees cover accommodation and selected meals (all lunches and 2 dinners):
250CHF (ETHZ/EPFL doctoral students),
350CHF external doctoral students; ETHZ/EPFL Mittelbau with a strong interest in writing.

Interested students are asked to develop a (textual or diagrammatic) concept sketch explaining the content and the form. The length of the text or the extent of the creative project will be decided upon individually.

For MSc ARCH students and Doctoral students.

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Number of participants limited to 12.
Enrolment in agreement with the lecturer only.
The elective deals with current transformation processes of metropolitan landscapes in Europe and introduces landscape architecture design on a territorial scale. On the basis of cartographic analysis and field trips, students will develop concrete strategies for the urban landscape of the Città Metropolitana di Torino.

Objective
The elective introduces to the subject and complexity of the urbanized landscape and teaches the critical engagement with the challenges and potentials of current tendencies in Landscape Architecture. On the basis of a concrete study area, students examine the large-scale processes of reuse, reform and reinterpretation of metropolitan landscapes in Europe, and develop new approaches and strategies on various scales. They become familiar with GIS as an analytical tool, model building as a design methodology and the representation of landscape through plans. They develop a project based on the perception of place, knowledge of landscape-architectonic typologies and conception of public space. The design process is accompanied by workshops, lectures, excursions, critiques and a workbook.

Content

Prerequisites / notice
The participation in the course is subject to the following three conditions:
1) The course is limited to 12 students. The restriction follows the time of inscription according to the first-come-first-served-principle.
2) A two-days trip to Turin is mandatory for all students, which will take place on the weekend of October 8-9.
3) The contribution to expenses will be max. 250.- CHF per student. In case of short-notice cancellation, these costs will be charged to the student.

Lecture notes
On the occasion of the publication of the forthcoming book 'Henri Lefebvre and the Theory of the Production of Space' by Christian Schmid, we are organising a special seminar in the autumn semester 2022 in which we will read and discuss the book together.

The book will be published by Verso in November 2022, and offers an encompassing, systematic, and accessible introduction to Lefebvre's theory of space and the urban. We will provide pre-print copies of the individual chapters to the seminar participants.

Henri Lefebvre developed an extraordinarily and far-reaching spatio-temporal theory of society that is today widely applied in humanities and social sciences, particularly in urban studies, human geography, sociology, cultural anthropology, political sciences, philosophy, literature, cultural studies and the arts, and also in architecture, urban design and planning.
Lefebvre's work as a collection of inspiring but disparate thoughts and reflections, this book starts from the thesis of coherence, assuming that this work is distinguished by a continuity of concepts and categories that are connected in a consistent way. It reveals the epistemological context of this theory in French philosophy and in the German dialectic (Hegel, Marx, and Nietzsche), and explores the historical development of the core concepts. It illuminates Lefebvre’s understanding of everyday life, the right to the city, the thesis of the complete urbanization of society, and the intrinsic relationship between space and the state. It explains the famous double triad of the production of space: perceived, conceived and lived space – and spatial practice, representation of space and spaces of representation. And it develops a dialectical matrix of a theory of society, which is today widely applied in humanities and social sciences, particularly in urban studies, human geography, sociology, cultural anthropology, political sciences, philosophy, literature, cultural studies and the arts, and also in architecture, urban design and planning.

For further information see: https://www.versobooks.com/books/4089-henri-lefebvre-and-the-theory-of-the-production-of-space

In order to make the seminar open to a wider audience, we are organising it hybrid – over Zoom and in-person.

Places are limited. Please send a short application expressing your interest in the seminar to bathla@arch.ethz.ch

052-0725-22L ACTION! On the Real City: Drawing With Light - Daylight and the Moving Image

Abstract
The word photography combines Greek roots photos, "light," and graphe, "represent by drawing lines". Photography is essentially "drawing with light."

We will encourage reflections on this topic by developing new forms of urban literacy integrating ethnographic research methods, filmmaking and other forms of digital media.
Objective

Through a combination of practical exercises in video and audio techniques in parallel with the study of seminal observation-driven texts, this course aims to equip students with the basic tools and core principles to create short but complex portraits of urban space. This semester, the focus falls on the topic of daylight, in all of the ways in which it affects everyday life - both indoors, outdoors, and everywhere in between.

This approach will be applied to experiments in filmmaking and photography. Through various audiovisual experiments, students will collectively speculate on ways to marry the various forms of research methods that traditionally do not intersect, creating mosaics of experimental research forms.

Using widely available recording tools and editing software, students will turn their fieldwork into short video or audio works of about 3-5 minutes.

Content

The course will consist of lectures, practical crash courses in media use and storytelling, and fieldwork sessions. The course will be a laboratory in the creation of short media works that aim to inform the architectural design process, working between the city and the studio in ONA. Students will be expected to complete all required work within the hours that the elective meets, with few requirements outside of the class hours.

Literature

Seminal texts include:

- 'Cross-Cultural Filmmaking' (Barbash, Castaing-Taylor)
- 'Acoustic Territories' (LaBelle)
- 'Ethnography: Principles in Practice' (Hammersley, Atkinson)
- 'Thick Description: Toward an Interpretative Theory of Culture (Geertz)

Fostered competencies

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<tr>
<th>Method-specific Competencies</th>
<th>Communication assessed</th>
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<tbody>
<tr>
<td>Cooperation and Teamwork assessed</td>
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<td>Negotiation assessed</td>
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<tr>
<th>Social Competencies</th>
<th>Adaptability and Flexibility assessed</th>
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<tr>
<td>Creative Thinking assessed</td>
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<td>Critical Thinking assessed</td>
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<tr>
<th>Personal Competencies</th>
<th>Self-awareness and Self-reflection assessed</th>
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<td>Self-direction and Self-management assessed</td>
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063-0761-22L Integrated Discipline HS22 in the Field of Landscape and Urban Studies (LUS)

Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.

Objective

Students gain an insight into the integrated disciplines of design in architecture together with landscape architecture.

Content

Design concepts ranging from architectural objects to urban planning are developed together with the discipline of landscape architecture. Depending on the task at hand different themes are investigated. The goal of the integrated discipline is to develop design solutions of a specific topic in landscape architecture, which have to be incorporated into the overall design submission.

052-0713-22L Serendipity: Zurich Pointcloud Video

Number of participants limited to 16 (due to technical equipment).

Course language: English or/and German

Abstract

Curating the Zurich with Point Cloud Video Animations. The Wahlfach Serendipity will investigate various sites in Zurich through the point cloud model archive available at the Chair of Prof. Christophe Girot. Students will select specific sites and the corresponding material in the archive to create short audiovisual animations.

Objective

The goal of the Serendipity Wahlfach is to enable students to develop skills in point cloud modelling integrating both sound and video techniques. Students will learn digital modelling together with sound and video techniques at the Media Lab of the Chair of Prof. Girot. This will allow them to select, imagine and present selected environments in short videos. The video installations will be assessed for their capacity to reveal the intricate complexity of the urban realm in Zürich. Through the use of precise modeling techniques based on laser-scanned data, students will learn to move iteratively towards a final video proposal of the site they have chosen that will compound topography, infrastructure and architecture. The final works will be part of a larger D-ARCH event combining video works from different periods ranging from the 1970’s until today. It will strengthen student’s knowledge about digital and video approaches while still considering the broader socio-ecological context of Zurich’s underground.
The elective course Topology in HS 2022 deals with the theory and perception of landscape architecture, focusing on current debates. This new approach to the underground modelling of existing buildings is opening new possibilities in contemporary architectural thinking. It addresses directly the capacity of the city of Zurich to cope with and accept its own underground realm. As a result, the underground realm revealed by student videos through selected point cloud models will reinforce the sense of a new reality to be tackled and integrated. Many of the underground realms constructed by our predecessors where not originally meant to be looked-at or to be understood as objects of aesthetic consideration. Most of these functional spaces were meant to be buried below the urban fabric and forgotten. The Wahlfach Serendipity will challenge the dominant attitude that has sought to hide the underground away from sight for so long. It will give students the opportunity to produce a video installation that will integrate the underground in a broader framework of architectural acceptance. The video installations will open the debate about existing underground structures and their meaning in contemporary society. The transience of human actions contrasts with the constant pulse of natural (physical and biological) processes, such as the growth of trees, the erosive force of the wind, the folding of mountains. In one place, movements of the most different dimensions meet, detach from each other or flow together. We humans have long since become part of these complex choreographies: We adapt the environment to our needs and thereby inscribe new flows of movement, rhythms and forms into the (urban) landscapes.

In this elective, dynamic aspects of landscape morphology are explored in different ways. How do we as architects orient ourselves in transcossal processes? With a selection of texts and films we dive into the topic and examine significant positions from dance, art and landscape architecture. In intense mini-workshops we will go into the landscape ourselves and test the relations of our own bodily movements to the space.

The Department of Architecture at the ETH through the Media Lab and LVML represents one of the longest standing laboratory in video teaching at D-ARCH. The philosophy of the serendipity Wahlfachis is to build on the strengths of the current archival material at hand and to reveal aspects of the underground still to be discovered and enhanced. The Wahlfach will aim at bridging the realms of architectural design and media, by promoting novel ways that will transform our vision and understanding of the Zurich underground.

A course booklet will be provided at the first introductory meeting. For further information, please see: https://girot.arch.ethz.ch

Course language: English or/and German (number of participants is limited!)

> The course ends earlier than usual but will compensate for this with increased intensity in the weeks before.

052-0715-22L  Topology: Choreographies of Landscape  ■  W  2 credits  2K  M. Uzor, C. Girot

Number of participants limited to: 20

Teaching languages: German and English.

The elective course Topology in HS 2022 deals with the theory and perception of landscape architecture, focusing on current debates. This elective gives students the opportunity to expand their knowledge in the area of landscape architecture. The transience of human actions contrasts with the constant pulse of natural (physical and biological) processes, such as the growth of trees, the erosive force of the wind, the folding of mountains. In one place, movements of the most different dimensions meet, detach from each other or flow together. We humans have long since become part of these complex choreographies: We adapt the environment to our needs and thereby inscribe new flows of movement, rhythms and forms into the (urban) landscapes.

In this elective, dynamic aspects of landscape morphology are explored in different ways. How do we as architects orient ourselves in transcossal processes? With a selection of texts and films we dive into the topic and examine significant positions from dance, art and landscape architecture. In intense mini-workshops we will go into the landscape ourselves and test the relations of our own bodily movements to the space.

Is offered until end of FS23. This summer school is suitable for Master and doctoral students only. Please register before 6.6.22.

The project addresses critical issues of urban planning by using cutting-edge technology for analysis and communication. Students actively engage with building and zoning regulations (i) reconstruct, (ii) reformulate and (iii) simulate/visualise in web-based 4D urban models) as well as maintain an ongoing exchange through (peer) review activities in class.

- Capture and analyse the past and present; design, present and discuss future living spaces in 4D.
- Read, understand, deconstruct and formulate new zoning and building rules (BNO)s.
- Set up an ArcGIS Urban model and integrate current and new urban rules and visualize/simulate development scenarios/variations of urban designs.
- Learn from students from different disciplines through teamwork and by peer-reviewing each other's work.
- System thinking through causal loops.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 116 of 2416
Content
This planned course addresses the crucial urban transformation issues of our time at the 10-minute-neighbourhood level. Technology, communication and online learning materials are leveraged and opportunities for online interaction are combined with traditional classroom teaching methods. The course can be taught as elective with exercise and as an integrated discipline in design classes. In addition, the online material can be used for self-paced learning.

(i) Students actively engage with building and land use regulations by reconstruction them in a 3D model, formulating new 3D regulations based on design and land use criteria, and simulating possible developments based on existing building criteria in 4D. As students from different disciplines work in teams and share knowledge through mutual work and peer reviews, they can learn from each other across disciplines.

(ii) Urban design lectures benefit from being relieved of the task of teaching students software as part of the design class.

(iii) The entire course program in architecture, landscape architecture, building information systems (all D-ARCH) and spatial development and infrastructure systems (D-BAUG) can benefit from this. It is also conceivable that, building on this, a joint program will be developed and offered in the future, with the integration/combo of City Energy Analysis (CEA) by Prof. Schlüter, LÖ-app by Prof. Menz, Enerpol Tool/Daylight by Prof. Klumpner, to name a few.

Prerequisites / notice
The course is offered in summer 2022 as an elective block course with exercises, in HS22 as an integrated discipline within the Klumpner design studio and in FS23 to choose between the elective course or the integrated discipline.

Places: 20 at the most
Group work: groups of two
Primary target groups: Master Architecture, Integrated Building Systems, Landscape Architecture, Master Spatial Development and Infrastructure Systems
Registration: until 06.06.2022
Waiting list: until 17.06.2022

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0587-00L</td>
<td>Workshop on Sustainable Building Certification</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>T. Gali-Izard</td>
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</table>

052-0732-22L  Housing Issues and Challenges in the Global South: Contributions of Architecture

W  2 credits  2V  J. E. Duyne Barenstein

Abstract
Can architecture, urban design and planning contribute to make housing and cites more equitable and inclusive? Answers to this question will be provided by socially engaged architects from Europe, Asia and Latin America through the presentation of concrete actions and projects.

Objective
The course aims at raising awareness about the multi-faceted manifestations and consequences of neo-liberal housing and urban policies. After a general introduction to the causes and consequences of the current global housing and urbanisation challenges, the students will learn through concrete examples that architects, planners and urban designers can make a difference. Socially engaged architects, designers and planners from Europe, Asia and Latin America will present actions and projects that contributed to make human settlements more inclusive, liveable and sustainable.

Content
The course will focus on the following topics:

- Global housing and urban challenges: an introduction
- From planning actions to the commodification of public spaces in Vienna
- Countering the financialization of the city of Berlin
- Un-gating the city: the case of Bogota, Colombia
- Creating public space for popular culture in Barranquilla, Colombia
- Designing lights and sites of publicness in Mali
- Architects' role in ensuring informal settlers' right to the city in Bolivia
- Architectural activism and the re-emergence of housing cooperatives in Spain
- Enhancing social inclusion through participatory urban design in Milano, Italy
- Urban environmental activism, architecture and housing cooperatives in Switzerland
- Learning from vernacular building practices in India and Latin America
- Rebuilding housing and communities after conflicts and disasters
- Architecture for reconciliation and peace building in post-conflict settings

Lecture notes
A course overview including lecture summaries is made available to inscribed students prior to the start of the semester.

Literature
A bibliography will be made available to inscribed students prior to the start of the semester.

052-0733-22L  Introduction to the Fundamentals of Natural Environment

W  1 credit  2V  T. Gali-Izard

This course is suitable for MSc and MAS UTD students only!

Only few places left! As of 13.9.22, please contact the chair converso@arch.ethz.ch.

Abstract
This course consists of a lecture series providing some fundamental knowledge in natural environment with experts and academics from various disciplines, such as geology, climate, ecology, soil and plant sciences.

Objective
Participants become acquainted with relevant issues and topics about the natural environment and gain valuable insights into the interaction of all living and non-living things, climate, weather and natural resources. The active participation in discussions following presentations allows participants to tackle relevant environmental challenges and discuss opportunities with academics and experts as well as to exchange ideas amongst the participants.

Content
This course is a series of lectures by academics and experts who present their research and fundamental knowledge across the field of the environmental sciences (geology, climate, ecology, soil and plant sciences). The active participation in critical discussions following each presentation allows participants to tackle relevant challenges in the natural environment with academics and experts.

Tuesday 20.9.22, 9-11:30: «Land-Climate Dynamics» with Dr. Jonas Schwaab, Dr. Gianluca Mussetti
Thursday 22.9.22 9-11:30: «Introduction to Geology» with Dr. Maria Giuditta Fellini, Dr. Vincenzo Picetti - Gebäude NO D1 (Sonneggstrasse 5 "Focus Terra")
Wednesday 5.10.22: 9-11:30: «Soil Biology & Ecology» with Dr. Aline Frossard
Thursday 13.10.22, 9-13:00: «Tree Architecture & Evolution» with Dr. Guillaume Chomicki
Friday 14.10.22, 9-11:30: «Plant Systematics I» with Alessia Dr. Guggisberg
Friday 21.10.22, 9-11:30: «Disturbance Ecology» with Dr. Thomas Wohlgemuth

Lecture notes
More details about each lecture, as well as keywords and topics relevant for and discussed during the lectures are published in advance on the course web page: mscla.arch.ethz.ch

The lectures are going to be live-streamed on Zoom: https://ethz.zoom.us/j/69300707903

Prerequisites / notice
No previous knowledge in environmental sciences is required.

Only few places left! As of 13.9.22, please contact the chair converso@arch.ethz.ch.

Technology in Architecture

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<tr>
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</table>
Abstract
Building labels are used to certify buildings and neighbourhoods in term of sustainability. Many different labels have been developed and can be used in Switzerland (LEED, DGNB, SNBS, Minergie, 2000-Watt-Sites). In this course the differences between the certification labels and its application on 3 emblematic case study buildings will be discussed.

Objective
After this course, the students are able to understand and use the different certification labels. They have a clear view of what the labels take into consideration and what they don't.

Content
Three buildings case study will be presented.

Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

After this overall general presentation and in order to have a closer look to specific aspects of sustainability, students will work in groups and assess during one or two weeks this specific criteria on one of the case studies presented before. This practical hands on the label will end with a presentation and a discussion where we will highlight differences between the labels.

This alternance of working session on one specific criteria for one specific building followed by a group presentation and discussion to compare labels is repeated for the different focus point (operation energy, mobility, daylight, indoor air quality).

Lecture notes
The slides from the presentations will be made available.

Literature
All documents for certification labels as well as detail plans of the buildings will be available for the students.

- **151-8015-00L  Moisture Transport in Porous Media**
  - **Abstract**
    - Moisture transport and related degradation processes in porous materials
    - Theory of moisture transport in porous materials
    - Experimental determination of moisture transport properties
    - Exercises on moisture transport properties determination:
      - Selected topics
        - Liquid transport in cracked porous media
        - Drying of porous media
        - Microclimate in urban street canyons
  - **Objective**
    - Basic knowledge of moisture transport and related degradation processes in porous materials
    - Knowledge of experimental determination of moisture transport properties
    - Application of knowledge to moisture transport in cracked materials, drying of porous media and microclimate in urban street canyons
  - **Content**
    1. Introduction
      - Moisture damage: problem statement, durability
      - Applications: building materials, soil science, geoscience
    2. Moisture transport: theory and application
      - Description of moisture transport
      - Determination of moisture transport properties
      - Exercises on moisture transport properties
    3. Special topics
      - Liquid transport in cracked materials
      - Drying of porous materials
      - Microclimate in urban street canyons
  - **Lecture notes**
    - Handouts, supporting material and exercises are provided online via Moodle.
  - **Literature**
    - All material is provided online via Moodle.
  - **Fostered competencies**
    - **Subject-specific Competencies**
      - Concepts and Theories
        - assessed
      - Techniques and Technologies
        - assessed
    - **Method-specific Competencies**
      - Analytical Competencies
        - assessed
      - Decision-making
        - assessed
      - Problem-solving
        - assessed
    - **Social Competencies**
      - Communication
        - not assessed
      - Cooperation and Teamwork
        - not assessed
    - **Personal Competencies**
      - Adaptability and Flexibility
        - not assessed
      - Creative Thinking
        - assessed
      - Critical Thinking
        - assessed
      - Integrity and Work Ethics
        - not assessed
      - Self-awareness and Self-reflection
        - not assessed
      - Self-direction and Self-management
        - not assessed

- **101-0577-00L  An Introduction to Sustainable Development in the Built Environment**
  - **Abstract**
    - In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict.
    - What does it mean for the built environment?
    - This course provides an introduction to the notion of sustainable development when applied to our built environment.
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content
The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

<table>
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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>052-0615-22L</td>
<td>Building Process: Realization</td>
<td>2</td>
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<td></td>
<td>The course is limited to 40 students. Enrolment is only possible in agreement with the lecturer (<a href="mailto:eglin@arch.ethz.ch">eglin@arch.ethz.ch</a>).</td>
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</table>

Abstract
Visits to construction sites and interdisciplinary lectures on the topics of communication, complexity, landscape and investment are the main focus of the workshop. In addition, the term process is to be depicted by means of visits to manufacturers of construction components.

Objective
The main focus of the diploma elective subject is in showing the building process by means of current examples of urban design with architectural relevance. The Chair views itself as the facilitator between those involved in construction and students. Active participation is a prerequisite.

Content
The main focus of the diploma elective subject is in showing the building process by means of current examples of urban design with architectural relevance. Visits to construction sites and interdisciplinary lectures on the topics of communication, complexity, landscape and investment are the main focus of the workshop. In addition, the term process is to be depicted by means of visits to manufacturers of construction components. The Chair views itself as the facilitator between those involved in construction and students. Active participation is a prerequisite.

Lecture notes
The recordings of the lectures are available on the MAP under the link https://map.arch.ethz.ch (book symbol at the top right).

Literature
https://map.arch.ethz.ch

Prerequisites / notice
The number of participants is limited and enrolment is only possible in agreement with the chair!

Introductory event: Participation in the introductory event is a prerequisite for this course!
Structure (Lectures, field work, final presentation) will be communicated in time.

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<td>CAAD Theory: Digital Epic - Creative Writing for Architects</td>
<td>2</td>
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</table>

Abstract
Architecture is already saturated in images. To properly articulate the digital cosmos of today what we need is writing and code.

Objective
The problem addressed in this course is how to allow the digital cosmos to find its voice, and how you as architects can inhabit this voice to speak both freely and carefully, both playfully and seriously, from word-building to world-building.

Content
No creative writing experience is required; you can forget everything you have learned. We will use experimental writing modes, movements and exercises to find ways to develop agility and grace in writing by testing the motility of concepts such as light and matter, gravity and grace, night and day.

You will form your own voices, forms and styles. We will all start with the initial theme of saturation. The digital cosmos is saturated. Saturation is extreme. Saturation is overwhelming. Saturation is beyond what is required.

Each week there will be a lecture followed by a group discussion. There will be a short text to read each week, and a short writing experiment to do. Readings will be provided online.

Lecture notes
http://www.caad.arch.ethz.ch

Literature
http://www.caad.arch.ethz.ch

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<tr>
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<tr>
<td>052-0629-22L</td>
<td>CAAD Practice: Operative Abstractions - From Aristotle’s Syllogism to Machine Learning</td>
<td>2</td>
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Abstract

Objective

Content

Lecture notes

Literature

Prerequisites / notice

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http://www.caad.arch.ethz.ch

Literature
http://www.caad.arch.ethz.ch

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</table>
This course aims to present the notion of abstraction as a central (operative) concept enabling our science, technology and lifestyle to transition to its 20th-century modalities. This notion will be illustrated with the example of a computer as a technical object. We will thoroughly show how computers work and what computer code is about within a broad multidisciplinary historical context. As the practical part of the course, we will be building a simulation of a computer from scratch using the most elementary logic circuits and the Logisim software. Then, we will design a computer language which will allow us to write programs for our computer. Finally, we will explore how, starting from such an elementary language, it is possible to develop all the complexity in contemporary computation, including machine learning.

lecture notes
http://www.caad.arch.ethz.ch

literature
http://www.caad.arch.ethz.ch

prerequisites / notice
No previous knowledge is required for joining this course.

<table>
<thead>
<tr>
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<td>052-0639-22L</td>
<td>Climate Responsive Architecture with Hive</td>
<td>1</td>
<td>2G</td>
<td>A. Schlüter, E. Borkowski</td>
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<td>063-0661-22L</td>
<td>Integrated Discipline HS22 in the Field of Technology in Architecture (ITA)</td>
<td>3</td>
<td>2A</td>
<td>Lecturers</td>
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<tr>
<td>052-0641-22L</td>
<td>Modeling: Reducing, Testing, Experiencing Architecture</td>
<td>2</td>
<td>2S</td>
<td>C. Daro, F. Gramazio, M. Kohler</td>
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Historic Building Archaeology and Conservation

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</thead>
<tbody>
<tr>
<td>052-0911-22L</td>
<td>Repair: Keep in Place</td>
<td>2</td>
<td>2S</td>
<td>S. Langenberg</td>
<td></td>
</tr>
</tbody>
</table>
Methods of Building Surveying

052-0915-22L

W 2 credits 2G  
C. M. Knobling

Surveying and measuring technologies in historical building archaeology.

Basic understanding of different surveying methods and first practical contacts with technical survey instruments.

The elective subject "Methods of Building Surveying" covers surveying and measurement methods ranging from simple hand measurements and tachymetry to laser scanning, terrestrial and drone-based photogrammetry and other non-invasive assessment methods such as thermal imaging. The different methods and technologies will be presented on the basis of current or completed research projects and their practical applications will be discussed. Internal and external guest speakers will report on their latest research projects in the field of building research and construction history. In the course of the elective, students will also have the opportunity to try out the methods themselves and integrate them into a small concluding project of their own.

The course is composed of theoretical and practical parts in and outside the classroom.

Literature

Baier, Andrea u. a. (Hg.), Die Welt reparieren. Bielefeld 2016.
Krebs, Stefan u. a., Kulturen des Reparierens. Bielefeld 2018.
Langenberg, Silke (Hg.), Repair. Encouragement to Think and Make. Berlin 2018.

Prerequisites / notice

ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h: Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

Number of participants limited to 40.

Fostered competencies

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Literture


Grahn, Wera u. a. (Hg.), Gender and Heritage, Performance, Place and Politics, ed. by Wera Grahn and Ross J. Wilson, London/New York 2018

Krebs, Stefan u. a., Kulturen des Reparierens, Bielefeld 2018.
Langenberg, Silke (Hg.), Repair. Encouragement to Think and Make. Berlin 2018.
Langenberg, Silke (Hg.), Repair. Encouragement to Think and Make. Berlin 2018.

Number of participants limited to 40.

Fostered competencies

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
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Number of participants limited to 40.

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Techniques and Technologies assessed
Analytical Competencies assessed
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Number of participants limited to 40.

Fostered competencies

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making assessed
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Self-direction and Self-management not assessed

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Number of participants limited to 40.

Fostered competencies

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Techniques and Technologies assessed
Analytical Competencies assessed
Decision-making assessed
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Krebs, Stefan u. a., Kulturen des Reparierens, Bielefeld 2018.
Langenberg, Silke (Hg.), Repair. Encouragement to Think and Make. Berlin 2018.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

063-0961-22L Integrated Discipline HS22 in the Field Historic Building Research and Conservation (IDB)
Enrolling in this course is only possible on agreement with the lecturer and if you attend a design course (V-IX) at the same time.

Abstract
The formal framework needs to be discussed with the staff members.

Objective
A study in building research and preservation of building heritage with a clear topic.

►► Focus Works

see Architecture MSc "Focus Work"

► Seminar Weeks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>Seminar Week Autumn Semester 2022</td>
<td>W</td>
<td>2 credits</td>
<td>3A</td>
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</table>

Abstract
The seminar week is obligatory for students of all semesters. There are many and varied study contents.

Objective
The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

►► Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ARCH

►► Language Courses

see Science in Perspective: Language Courses ETH/UZH

Architecture Bachelor - Key for Type

| O   | Compulsory | E-  | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended | Z   | Courses outside the curriculum |
| W   | Eligible for credits | Dr   | Suitable for doctorate |

Key for Hours

| V   | lecture | P   | practical/laboratory course |
| G   | lecture with exercise | A   | independent project |
| U   | exercise | D   | diploma thesis |
| S   | seminar | R   | revision course / private study |
| K   | colloquium |       |                           |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
History of Art and Architecture V: Caractère (Character)

**Objective**
- Deepen basic knowledge, improve ability to critically read and analyze texts of architectural theory, and understand shifts in architectural thinking.

**Content**
- ‘Caractère’ or character is not only a quality applied to human beings. It is also a category of architectural discourse, developed in the 18th century when architects and theorists were seeking new ways to talk about and judge buildings, pushing architectural discourse beyond Vitruvian categories to which it had been tied for centuries before.

This reading class will closely examine key texts that discuss the phenomenon of a building's 'character' from the 1700s up until today. The weekly assigned texts (in the original French, English or German) will be read at home and then discussed in class. Independent reading and vivid participation in class are a fundamental prerequisite. In addition, there will be weekly written assignments, which will all be graded. A final written assignment at the end of the semester will be graded as well. To pass the course, students will have to read each assigned text, and hand in all written assignments on time.

History of Art and Architecture VII

**Objective**
- Deepen basic knowledge, improve ability to critically analyze architectural history texts, develop humanities-based reasoning and argument skills, especially persuasive writing.

**Content**
- Antiquity and Medieval: Imagining History and Inventing Architecture

In the Renaissance, the practice of architecture fundamentally transformed into the design-based discipline it is now largely assumed to be. Both then and especially in nineteenth- and twentieth-century architectural history, this change was understood in opposition to 'good' ancient and 'bad' medieval models. This course investigates Antiquity and the Middle Ages as variously fashioned in the mind of the architect and the architectural historian. How does our understanding of these periods inform our thinking about the use of history for the contemporary architect?

This course is a combination lecture, writing, and discussion class: one brief text per week will be read at home and discussed in the course meeting. Short critical writing assignments will be assigned in the first half of the semester, and the final assignment is a short paper due during the January exam period. Written assignments will be scheduled to accommodate studio deadlines, and may be completed in English, German, French, or Italian. Active in-class participation is required.

Literature: Scans of the weekly readings will be made available on the course website.
This course offers a brief introduction to contemporary urban problems and challenges. Based on a thematic approach, the course explores how these issues pose a challenge to the fields of architecture, urban design and planning.

It is a somewhat commonplace to say that we live in an ‘urban age’: cities are the most common habitat for the inhabitants of the world, today. Moreover, while more than half the global population lives in cities according to the reports of the UN, it is expected that within the next few decades this amount will increase to two-thirds. This ‘urban’ condition, however, cannot be generalized. Within the term ‘city’ a broad range of different urban conditions are taken together: from metropolises to suburban neighborhoods, and from shrinking (old industrial) cities to the new cities that prosper under the conditions of globalization. It also generalizes too much with regard to the urban condition within cities in the so-called Global North as compared to the Global South. In other words: the urban condition is as diverse as there are cities. However, it is also true that it is precisely in the cities that the challenges of our time are most apparent: globalization, gentrification, poverty, climate change. These topics call for a response.

The development of cities forms the topic of discussion, not only within the fields of architecture, urban design, spatial planning, but also among politicians, economists, anthropologists, philosophers, citizens and activists. The urban realm and reality has provoked them to think and write about its form and functioning, appearance and structure, to protest against particular issues, and to take initiatives to direct the development in a different direction. Designers and planners reflect on the urban developments as well, sometimes in participating in the development themselves, sometimes from the sidelin e.

This is obviously not new, nor limited to the current urban condition. The discourse regarding the size and growth of cities, its functioning and politics, has a long pedigree in history, going back to the establishment of Greek and Roman city-states. This survey course aims to offer an introduction to issues at stake in cities, tailored to students of architecture and urban design. It will explore the past and current discourses, and will access a broad range of perspectives. It also does an effort to expand the scope beyond regular Western-European and North-American perspectives from Western world. The course will specifically address how architecture (positively or negatively) is involved in these issues.

The aim of the course is to challenge the question how architects and urban designers can have an influence on urban developments and issues that we often regard as beyond the scope of architecture. With this challenge, also students are urged to reflect upon their own position regarding architectural interventions in the urban fabric, facing the current condition of the urban environment (in all its diversity).

This course consists of weekly, one-hour lectures that address one particular topic at a time. In each lecture, this theme is investigated through different texts and case-studies that highlight crucial moments in the history and developments of cities. At the same time, the case studies will be structured so as to bridge between urban theories and concrete urban situations, design reflections and political ambitions. This will help convey to students the historical pedigree of current discourses on cities, whether simultaneously gain insight the role of designers and politicians, within cities in the so-called Global North as compared to the Global South. In other words: the urban condition is as diverse as there are cities. However, it is also true that it is precisely in the cities that the challenges of our time are most apparent: globalization, gentrification, poverty, climate change. These topics call for a response.

The course is finalized through the writing of an essay, wherein the student is challenged to question how architectural agency can address (a) contemporary urban issue(s).

For this course, each week students will read fragments from key readings on the topics addressed. The readings will be made available via the website of the course prior to HS2022.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

063-0803-22L History and Theory in Architecture IX: Neighborhood - Towards an Exhibition

Abstract
The Swiss Pavilion with the title "Neighborhood" for the 2023 Architecture Biennale is curated by Karin Sander and Philip Ursprung. The Swiss Pavilion shares a wall with the neighboring pavilion of Venezuela. The lecture deals with the process of conception and realization of the exhibition.

Objective
Knowledge of contemporary discourse on architecture exhibitions.

Content
The Swiss Pavilion with the title "Neighborhood" for the 2023 Architecture Biennale is curated by Karin Sander and Philip Ursprung. The topic originates in the fact that the Swiss Pavilion, by Bruno Giacometti, is sharing a wall with the neighboring pavilion of Venezuela by Carlo Scarpa. The spatial proximity of the two buildings from the 1950s raises questions about the meaning of neighborhood. The lecture deals with the process of conception and realization of the exhibition and reflects on the conditions and possibilities of architectural exhibits in general.

Field of Historic Building Research and Conservation

Number Title Type ECTS Hours Lecturers
063-0911-22L Future Monuments W 2 credits 2V S. Langenberg

Abstract
Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice.

Objective
In addition to active participation in the discussions, students will be asked to engage with a topic or object of their own choice in order to be able to develop and comprehensibly justify their own positions within the context of preservation. Our goal here is to foster students' communication skills and the culture of discussion.

Content
The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. This core conveys this knowledge to students with the help of selected writings and discusses them in the context of various guest lectures. In addition to dealing with historical buildings, the course is also dedicated to younger (and very young) objects and inventories - for in addition to the preservation of already listed objects, the selection and inventorisation of future protected objects is also one of the core tasks of heritage conservation.
Literature

READING LIST

Monographs and edited volumes:


Dehio, Georg, Kunsthistorische Aufsätze. München 1914


Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohlleben, Marion und Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:

Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008

Stadt Zürich Hochbaudepartement, Amt für Städtebau (Hg.), Bauten, Gärten und Anlagen 1960 bis 1980. Inventarergänzung, August 2013


Die Kunstdenkmäler der Schweiz

INSA – Inventare der Heimatkantone der Teilnehmenden
Abstract
History of the construction site and its technology

Objective
Introduction to Construction History and the so-called "building archeology": ability to perform a "cloe reading" of historic built fabric, based on an in-depth knowledge on historic production techniques, both in the workshop and on the construction site itself.

Content
This lecture series deals with the history of the production of buildings. This history draws heavily on pictorial and archival sources, but the lecture will always establish the link to traces observable on site. In that sense, the lecture is an introduction to the wide topic of "building archeology". Among others, we will cover the following topics:

- construction materials, tools and tooling of construction elements
- material flow and economic boundary conditions of the construction site
- construction site technology and construction machinery (scaffolding, cranes, etc.)
- historic methods of architectural planning
- history of building production

This lecture is closely related to current research projects.

Lecture notes
PDFs of the lecture slides will be provided before the lecture. Furthermore, the audience will be granted access to recent journal articles and book chapters providing in-depth insight into the topics covered by the lecture.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed
Content

We study historic constructions in German-speaking Switzerland (individual small groups, objects within 2 hrs public transport reach from ETH Hoenggerberg). Each group will be assigned an individual tutor (PhD student) who will be present on-site, on individual appointment.

We will survey, document and analyze a historic construction, with particular attention to production traces, constructive detail and load-carrying system.

We will start with introductory classroom lectures and on-site teaching during the first third of the semester. This will be followed by individual investigations on site. The progress will be pinpointed in three critiques:

1) on site, with individual tutor
2) at institute, with professor and institute members
3) final delivery, at institute, with professor and all institute members

The detailed schedule of the case studies can be found here:


Lecture notes

Each enrolment obliges the student to visit all compulsory dates during the entire semester without interruption.

Detailed instructions on on-site investigations, as well as manuscripts on the background, will be provided. It is mandatory to read them in due time!

Literature

Will be announced during the introductory lectures

Prerequisites / notice

Elementary knowledge of architectural history and construction.

Semester program:

25.9.20: On site introduction, Rümlang (Glattbrücke).
Courses in HIL E 7 until end of October.
Group work on the object or individual work (at home).

Intermediate crits and final crits at the IDB (HIT, H Level). Details will follow in due time.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies

- Adaptable and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Field of Landscape Architecture and Urban Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

The Chair of Sociology presents a review of two decades of social and urban research at the Department of Architecture, ETH Zurich. This lecture series will host researchers who will present the methods, experiences, and findings from some of the important urban research projects undertaken at the Department over the last two decades.

Objective

The lecture series, Methods of Urban Research presents the methodology of sociological analysis developed over the years by the Chair of Sociology, which can be used in architectural and urban design. It provides practical experience with the results of the SNSF study on the analysis of urban qualities and discusses the topicality of the ETH Studio Basel's urban portrait of Switzerland. Further, it provides an insight into international research on urbanization processes in large metropolises and in territories characterized by extensive urbanization. The synopsis provides a kaleidoscopic overview of the diverse methods used in urban research today.

In order to receive a grade for the seminar, the participants are expected to work in groups of two and are required to submit a five-page (2000 words) report summarizing a method(s) they found relevant in the lecture series. Please make a description and a critical analysis of this method and make a proposal how to apply it to a topic and a site of your choice.
22.09.  Die Anfänge: Öffentliche Räume und Zürich West
Christina Schumacher, Bernadette Fülscher, Verena Poloni und Cordula Püstow

29.09.  21 Years of Urban Sociology at the Department of Architecture
Christian Schmid

06.10.  The Young Housing Cooperatives in Zürich and the INURA Coop Initiative
Ileana Apostol and Philipp Klaus

13.10.  Soziologie im Entwurf: Methoden und Erkenntnisse
Caroline Ting

20.10.  Ethnography and Urban Research
Alice Hertzog and Lindsay Howe

03.11.  ETH Studio Basel und das städtebauliche Portrait der Schweiz
Emanuel Christ, Mathias Gunz, Christian Müller Inderbitzin and Milica Topalović

10.11.  Vergleichende Stadtfor schung und experimentelle Methoden
Monika Streule

17.11.  Urbane Qualitäten: Ein Forschungsprojekt
Lukas Küng, Simon Kretz und Thomas Kissling

24.11.  Zürich erforschen
Gabriela Muri Koller

01.12.  Journeys through Extended Urbanisation
Nitin Bathla

08.12.  Final Discussion

063-0703-22L Architecture of Territory: Territorial Design in Histories, Theories and Projects
Abstract
This lecture series sets up an agenda for widening the disciplinary field of architecture and urbanism from their focus on the city, or the urban in the narrow sense, to wider territorial scales, which correspond to the increasing scales of contemporary urbanisation. It discusses the concepts of territory and urbanisation, and their implications for the work of architects and urbanists.

Objective
The course will enable students to critically discuss concepts of territory and urbanisation. It will invite students to revisit the history of architects’ work engaging with the problematic of urbanising territories and territorial organisation. The goal is to motivate and equip students to engage with territory in the present day and age, by setting out our contemporary urban agenda.

The lectures are animated by a series of visual and conceptual exercises, usually on A4 sheets of paper. All original student contributions will be collected and bound together, creating a unique book-object. Some of the exercises are graded and count as proof of completion.
Within the theme MY ENERGY, the four guest speakers engaged in fields ranging from energy humanities and feminist political ecology to urban history and urban design, will approach the notions such as energy transition, decarbonisation, genealogy of energy, and urban microclimates.

22. 09. 2022
On Territory
MILICA TOPALOVIĆ

29. 09. 2022
Architecture and Urbanisation
MILICA TOPALOVIĆ

06. 10. 2022
Methods in Territorial Research and Design
MILICA TOPALOVIĆ

13. 10. 2022
Exploring Energy Ecologies
Guest lecture by SASCHA ROESLER

20. 10. 2022
Spaceship in the Desert: Energy, Climate Change and Urban Design in Abu Dhabi
Guest lecture by GÖKÇE GÜNEL

03. 11. 2022
Planetary Urbanisation: Hinterland
MILICA TOPALOVIĆ

10. 11. 2022
Disappearance of the Countryside
MILICA TOPALOVIĆ

17. 11. 2022
Metropolitan Repair
MILICA TOPALOVIĆ

24. 11. 2022
Energy Matters
Guest lecture by EVA PFANNES

01. 12. 2022
The Birth of Energy
Guest lecture by CARA DAGGETT

08. 12. 2022
Our Common Territories: An Outlook
MILICA TOPALOVIĆ

Prerequisites / notice

The lectures will take place on Thursdays, 10.00-12:00, at ONA Fokushalle E7 and on ZOOM.

Lecturer:
Prof. Milica Topalovic

Team:
Prof. Milica Topalović, Dr. Nazlı Tümerdem

Student Assistants:
Michiel Gieben and Quianer Zhu

Contact:
Nazlı Tümerdem
tuemerdem@arch.ethz.ch

Zoom Meeting ID: 694 4625 4529

Our website:
https://topalovic.arch.ethz.ch

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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Field of Technology in Architecture

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</tr>
</thead>
</table>

Abstract
Urban physics: wind, wind comfort, pollutant dispersion, natural ventilation, driving rain, heat islands, climate change and weather conditions, urban acoustics and energy use in the urban context.

Objective
- Basic knowledge of the global climate and the local microclimate around buildings
- Impact of urban environment on wind, ventilation, rain, pollutants, acoustics and energy, and their relation to comfort, durability, air quality and energy demand
- Application of urban physics concepts in urban design
The course is centered around a design exercise where the form should be the result of the flow of internal forces and the detailing concept.

Building Process: Economy

This course presents the potentials of combining graphic statics with computational tools.

3 credits

J. Schwartz

The recordings of the lectures are available on the MAP under the link https://map.arch.ethz.ch (book symbol at the top right).

3G

P. Block

To grasp the coherences of costs, income and income return.

"Skript Tragwerksentwurf I&II"

http://www.block.arch.ethz.ch/eg/course/4/?lang=en

Printed versions can be bought at the chair of Structural Design Prof. Schwartz.

Autumn Semester 2022
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

Computational Methods of Energy- and Climate Design

As of FS23, this course will be offered in spring semesters only.

Abstract
The course 'Energy- and Climate Systems III' introduces computational design and analysis methods and tools for climate responsive architectural design. Exercises throughout the semester allow applying new concepts learnt in exemplary architectural design tasks.

Objective
By the end of this course, students will be able to:
- compare and assess passive and active design strategies for bioclimatic buildings
- analyze environmental site characteristics for its climate and (solar) energy potentials
- apply computational simulation tools to support performance-driven designs
- translate design ideas into parametric models and into optimization problems
- synthesize learnt content of the course in exemplary architectural design tasks, serving as a basis for the students' future design studios and projects

Content
1. Concepts of climate responsive design
2. Computational analysis methods
   - Climate and site analysis
   - Daylight, airflow and energy simulations
   - Energy supply systems optimization models (energy hub)
3. Computational methods for performance driven design
   - Parametric design
   - Sensitivity and uncertainty analysis
   - Single and multi-objective optimization
4. Exercises and walkthroughs
5. Invited expert speakers and panel discussion

Prerequisites / notice
ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h:
Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

We will offer weekly 1h tutorial / practice sessions in the HIB open space to recap necessary background knowledge (simple statistics, Rhino & Gh modelling), as well as to practice tools and methods learnt in class. Dates to be announced later.

Requirements and Recommendations:
MSc Arch:
- Successfully completed the online blended learning course 'Climate responsive architecture with Hive' beforehand (Requirement)
- Successful participation in the course 'Energie- und Klimasysteme I + II' (Recommendation)

MSc MIBS / Eng:
- Successfully completed the online blended learning course 'Climate responsive architecture with Hive' beforehand. (Recommendation)
- Successful participation in the course 'Building Systems'. (Recommendation)

All students need to be capable of working with 'Rhinoceros 3D' & 'Grashopper' on 'Windows' or willing to acquire the necessary skills before or during the course.

The Digital in Architecture II

Prerequisite: Successful completion of the course "Structural Design VI" (063-0606-00L), "Design III" (052-0541/43/45) or "Das Digitale in der Architektur" (063-0610-00L).

Abstract
Subject of the course is robotic fabrication in architecture. Through exercises, basic skills such as robotic control are being taught and applied to a small design and fabrication project. The course teaches how to develop a simple fabrication and material aware digital design process linked to a robotic fabrication procedure.

Objective
Students learn to use industrial robots such as the Universal Robot UR5 and understand basic principles of robotic control. At the end of the course, students are able to translate simple design ideas into robotic fabrication processes, which they can run independently. Furthermore students deepen their skills in Python and Grasshopper.

Prerequisites / notice
ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h:
Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

Architectural Design

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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>063-0655-22L</td>
<td>Subject Semester HS22 (Fachsemester) in the Field of History and Theory in Architecture gta(Delecke)</td>
<td>W</td>
<td>14</td>
<td>29A</td>
<td>M. Delbeke</td>
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<td></td>
<td>Allocation only after consultation with the professor (meetings as required and after consultation with the chair).</td>
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<td></td>
<td>A student can only register once for a &quot;Fachsemester&quot; during the Master studies!</td>
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</tbody>
</table>
Upon successful completion of the subject semester, students will be able to identify concepts and relevant design parameters for zero-emission building design and develop integrated architectural design strategies. They will know how to select and use appropriate simulation and analysis tools to qualify and quantify their design solutions and will be able to visualize their concepts with both technical schematics and architectural drawings and visualizations.

The application deadline for this "Fachsemester" is September 7, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by Tuesday, September 6, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class.

A student can only register once for a "Fachsemester" during the Master studies!

Places for this "Fachsemester" are limited. If you are interested in taking part, please send us an email with a 300-word motivation letter including an initial topic proposal to: professur.delbeke@gta.arch.ethz.ch

If you already have a specific case study in mind, please describe what this is. If not, you can describe a general idea or area of interest, and we will help you find a more specific object of study during the course sessions.

The sole stipulation is that the topic period should date from before 1850.

The application deadline is Monday, September 5, 2022, 2 p.m. You will receive a message about acceptance or rejection for the subject semester by Tuesday, September 6, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class.

A student can only register once for a "Fachsemester" during the Master studies!

The application deadline for this "Fachsemester" is September 7, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by Tuesday, September 6, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class.

Subject Semester HS22 (Fachsemester) in the Field of Technology in Architecture (ITA, Prof. Schlüter)

A student can only register once for a "Fachsemester" during the Master studies!

The application deadline for this "Fachsemester" is September 7, 8 p.m. You will receive a message about acceptance or rejection for the subject semester by Tuesday, September 6, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class.

A student can only register once for a "Fachsemester" during the Master studies!

Upon successful completion of the subject semester, students will be able to identify concepts and relevant design parameters for zero-emission building design and develop integrated architectural design strategies. They will know how to select and use appropriate simulation and analysis tools to qualify and quantify their design solutions and will be able to visualize their concepts with both technical schematics and architectural drawings and visualizations.
The subject semester kicks off with an introduction to the use and exploitation of building systems for the design of zero-emission buildings. The goal of the semester is to demonstrate the relationships between building systems and architecture and to find ways to manifest building systems in design.

Students begin with a research and mapping phase in which they first investigate various building systems for zero-emission building design. They then map the building systems with architectural parameters for successful interaction between the two and create a catalog of their findings.

After the research and mapping phase, students design a small building in which they explore how to maximize the interactions between the building systems and the architectural parameters. Finally, students attempt to quantify their design solutions using low-threshold modeling, simulation, and optimization tools such as Rhino/Grasshopper or HIVE. To assess and discuss their concepts not only numerically but also architecturally and aesthetically, students also find appropriate forms of visualization.

Students document the process and results both numerically and architecturally, which are then discussed with a final jury.

Apply with a brief letter of motivation by 8 p.m. on September 7, 2022, to: illias.hischier@arch.ethz.ch. Your participation in the subject semester will be confirmed by September 9, 2022.
A student can only register once for a "Fachsemester" during the Master studies!

Available places will be allocated firstly conform the A-B-C-studio priority system, and secondly, if necessary, randomly. You will receive a message about acceptance or rejection for the subject semester by Thursday, September 8, 2021, 2 p.m. at the latest. Students who have been rejected have the opportunity to choose a design class.

Abstract

Zürich’s Land Commons

This Research Studio focuses on the land commons of Zürich and explores how the ways in which land is managed and appropriated influences the construction of the city. What are land commons and how do architects and how do architects and other citizens engage with them? How do they help us in addressing the social, political, and environmental challenges of our time?

Objective

The Research Studio has two main objectives:

First, to develop an ‘Archeology’ of Zürich’s land commons. In this part, the work of the urban historian or theoretician is understood as an archaeological venture. The collective stock of Zürich’s variegated land use, as well as the crafts and realizations (buildings and neighborhoods) related to it, will be systematically analyzed as the outcome of codes and as reliant on established practices of ‘commoning’. The result will be a catalogue of the city’s common-pool land resources, illustrating how these provide a basis for practices of ‘commoning’ and how, as architectural, and urban figures, they are integrated into and have an impact upon the city fabric.

Second, to identify a ‘Project for the City’. Based on the archeology, we will explore the inherent logics of the land commons of Zürich. The idea is that the uncovering of these logics not only helps to comprehend the historical development of the land commons, but also to integrate and cultivate these logics for future generations. On the basis of the research, students will be able to develop an architectural hypothesis of the developments in the city of Zürich.

Cities have always been places based on common resources. While designing and constructing the architecture of the city, urban designers, builders, and inhabitants have had to engage with common resources located in particular places and geographies: inherited common-pool resources (water, nature, air); material common-pool resources (clay, brick, stone, wood); as well as immaterial common-pool resources (craft, knowledge).

This understanding of the city, as being intrinsically related to common resources has gained renewed attention, as neoliberalism replaces ever-shrinking welfare structures, and global urbanization is accompanied by rising inequality. It is not only architects and urban designers who are again becoming interested in alternative principles of governing common resources, but also political movements and society at large. Hence, some of these issues – generally labeled ‘the commons’ – have received growing attention in the last decades within the fields of critical urban studies, urban history, urban geography and the social sciences.

After four semesters focusing on the water commons, the green commons, the housing commons, and the material commons, this Research Studio continues the investigations into the rich history of ‘the commons’ in the city of Zürich by focusing on its land resources. The ‘land commons’ will be investigated from architectural, urban, typological, environmental, and material perspectives. We will explore how common practices have affected the development of the city, and conversely how land commons enable and structure common practices. Ultimately, this historical research will unlock an alternative reading of the urban and architectural qualities of the built environment of the city, potentially pointing to more socially inclusive and environmentally conscious alternatives to the mostly market driven land use of the city.

Lecture notes

Methodology: Exploring the Tools and Knowledge of the Architect

The main hypothesis of the Research Studio is that historical and theoretical research can gain from a profound use of the tools and knowledge of an architect. During the Research Studio students will employ specific architectural tools, such as drawing, writing, and model making to explore historical and theoretical realities. Students will be urged to explore various methods of composing analytical and interpretative drawings. They will reflect upon the capacity of drawing methods from the field of architecture, such as plan drawing, sectional drawings, mappings, serial visions, public drawings, diagramming and perspective representations to act as tools of historical and theoretical research. At the same time, they will be asked to investigate various analytical and interpretative modes of scale-model making. Students may work with different types of models (structural models, mass models, counter form models, landscape and territorial models) as ways to historically or theoretically explore the reality of the city.

Far from being simple graphic or artefactual restitutions of the city, these drawings and models will create morphological, thematic or theoretical links between various occurrences in the city. These methods of drawing and model making will be combined with more conventional investigative techniques in the fields of history and theory such as discourse analysis, iconographic studies and compositional investigation, to support a better historical or theoretical understanding of specific occurrences and conditions in the city of Zürich.

Students will also be stimulated to use their spatial, formal, material and constructive architectural knowledge to offer alternative historical or theoretical interpretations of the reality that they encounter in the archives, in the library or in the city. They will be asked to activate their specific spatial, typological, compositional, technical, material and constructive expertise to probe into the various historical layers of the architecture of the city in newfangled ways.

Within the general theme of land commons, students will be guided to identify their own subtheme, as well as explore their own different methodologies of doing research. During the Research Studio students will confront their empirical knowledge (about space, typology, composition, technique, material and construction), pertaining to the autonomy of architecture, with other types of knowledge (on politics, economy, the social and cultural) that belong to the heteronomy of architecture. In the relation between autonomous and heteronomous knowledge, a new understanding of the city will be constructed. The combination of these tools and methods will offer an in-depth mode of historical and theoretical research, wherein the students will retroactively explore the spatial, formal, material and constructive features of a particular situation to uncover and reconstruct the logics that have led to a certain urban condition. On the basis of this research, students will be able to develop an architectural hypothesis of the developments in the city of Zürich.

Course syllabus and reader will be made available during the course's first week.

A student can only register once for a "Fachsemester" during the Master studies!

The studio is self-dependent work and tutoring takes place on Tuesdays and Wednesdays.

Enrollment will not take place through the D-ARCH website. To enroll for this Fachsemester please send an e-mail to sanna.kattenbeck@gta.arch.ethz.ch by Wednesday 7th September 2022, 8 p.m. Available places will be allocated firstly conform the A-B-C-studio priority system, and secondly, if necessary, randomly. You will receive a confirmation by Thursday 8th September 2022, 2 p.m. In case of over-applications, students who are not selected will have the opportunity to choose a regular design studio through the D-ARCH website.

https://avermaete.arch.ethz.ch/researchstudio
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: not assessed
- Self-direction and Self-management: assessed

Focus Work

Realization in the respective fields of the institutes. Definition of topics by professors, in consultation with the students. The content may also refer to an elective course.

The performance assessment comprises either a purely written examination followed by an oral examination or a creative, manual or drawing work, including a description, followed by an oral examination. At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and knowledge gained.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

Field of Historic Building Research and Conservation

Definition of topics by professors, in consultation with the students (student’s proposal / content of an elective course).

Performance assessment: Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

Information on exams and grades: Art. 29 of the MSc D-ARCH regulations.

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</table>

Field of Design and Architecture

Definition of topics by professors, in consultation with the students (student’s proposal / content of an elective course).

Performance assessment: Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

Information on exams and grades: Art. 29 of the MSc D-ARCH regulations.

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<td>13A</td>
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</tbody>
</table>
In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4. It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term "dropout".

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one "in-depth study" course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The topic is determined in consultation with the chosen professor.

### Field of History and Theory of Architecture

**Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).**

**Performance assessment:** Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

**Information on exams and grades:** Art. 29 of the MSc D-ARCH regulations.

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<td>6 credits</td>
<td>13A</td>
<td>Supervisors</td>
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</table>

**Abstract:** Indentation work of the Institute gta, of which the content can also refer to an elective subject.

**Objective:** Development of skills and competences in a special area / sub-area of architectural theory or practice.

**Content:** In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4. It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term "dropout".

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one "in-depth study" course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The topics can be proposed by the students.

In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

### Field of Landscape Architecture and Urban Studies

**Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).**

**Performance assessment:** Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making

European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

The documents for the lecture will be provided at the moodle.

Recommended literature:
- Governance models:
  - Governance models:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

Planning systems in Europe:
Fostered competencies

**Subject-specific Competencies**
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed

**Method-specific Competencies**
- Analytical Competencies
  - assessed
- Decision-making
  - assessed

**Social Competencies**
- Communication
  - assessed
- Cooperation and Teamwork
  - assessed
- Self-presentation and Social Influence
  - assessed
- Sensitivity to Diversity
  - assessed
- Negotiation
  - assessed

**Personal Competencies**
- Adaptability and Flexibility
  - assessed
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - assessed
- Self-awareness and Self-reflection
  - assessed
- Self-direction and Self-management
  - assessed

Focus Work HS22 in the Field Landscape and Urban Studies (LUS)

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<tr>
<th>Number</th>
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<td>6</td>
<td>13A</td>
<td>Supervisors</td>
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**Abstract**
Indentation work of the Institute LUS, of which the content can also refer to an elective subject. The topic is determined in consultation with the chosen professor.

**Objective**
Development of skills and competences in a special area / sub-area of architectural theory or practice.

In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination.

At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4.

It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term “dropout”.

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one “in-depth study” course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

The subjects can be proposed by the students.

In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

Taking place from 10.-28.1.22 in ONA G25.

**Field of Technology in Architecture**

Definition of topics by professors, in consultation with the students (student's proposal / content of an elective course).

Performance assessment: Purely written examination followed by an oral examination OR a creative, manual or drawing work, including a description, followed by an oral examination.

At least one focus work is a written work followed by an oral exam. The written work fulfills the criteria of a scientific paper in a formal sense. In addition to the design, crafting or drawing part, it also includes a written description of the question, methodology and possibly gained knowledge.

A creative, crafting or graphic focus work is shown in a public exhibition, a purely written focus work is accessible to the public.

Information on exams and grades: Art. 29 of the MSc D-ARCH regulations.
In-depth work is carried out in the respective subject areas of the institute. The professors determine the topics in consultation with the students. The content of the in-depth work can also relate to the content of an elective course.

The performance assessment comprises either a purely written work with a subsequent oral examination or a creative, technical or graphic work, including a description, with a subsequent oral examination. At least in the case of one in-depth thesis, the performance assessment must take the form of a purely written work with a subsequent oral examination (Regulations Paragraph 2 Letter a). In formal terms, the written work must meet the criteria of an academic paper. In addition to the creative, manual or drawing part, it includes a written description of the question, the methodology and the possible gain in knowledge of the work.

The students take the oral examination with the professor with whom they have discussed the topic of the in-depth thesis.

The written or creative, manual or drawing work and the oral examination are each assessed individually. These two assessments are offset against each other and result in the overall grade for the in-depth work. Paragraph 7 remains reserved.

The oral examination can only be taken if the written work or the creative, technical or graphic work is sufficient.

A thesis is passed if the overall grade is at least 4. It is considered not passed if the overall grade is below 4; if the written or creative, technical or graphic work is unsatisfactory and therefore the oral examination cannot be taken; in such a case, the failure will be noted with the term "dropout".

An in-depth thesis that has not been passed cannot be repeated. In order to acquire the required CP, a further in-depth work must be carried out and the performance must be assessed with an overall grade of at least 4. The number of attempts is limited (see regulations).

If more than one "in-depth study" course unit is not passed, the course is considered to have been definitively failed, which leads to exclusion from the course.

The creative, craft or drawing in-depth work is publicly exhibited. Purely written in-depth theses are made publicly available.

Prerequisites / notice

The subjects can be proposed by the students.
In consultation with the professors of architecture, the fixed topics are binding (see Art. 29 Reg. 201 MSc Architecture).

**Master's Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>063-0141-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>40D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Ultimate deadline to unsubscribe or enroll for the Master Thesis is 16.11.22.
Deleting a reservation after this date is prohibited.

The master's thesis is the completion of the Master's degree.

It shows the students' ability to work independently and is a proof of the successful completion of their studies.

The Master's thesis is supervised by a design professor D-ARCH. The students can choose one of the topics presented by the D-ARCH or - after approval by the head of the work - a free, self-chosen topic. Further details are regulated in Articles 31-38.

**Electives**

see "electives" in Architecture BSc

**Seminar Weeks**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>051-0911-22L</td>
<td>Seminar Week Autumn Semester 2022</td>
<td>W</td>
<td>2</td>
<td>3A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

The seminar week is obligatory for students of all semesters. There are many and varied study contents.

The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

**Science in Perspective**

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ARCH

see Science in Perspective: Language Courses ETH/UZH

**Course Units for Additional Admission Requirements**

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-1100-AAL</td>
<td>Architectural Design V-IX (Part 1)</td>
<td>E</td>
<td>14</td>
<td>16U</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php)

Project grading at semester end is based on the list of enrolments on 1.11.22 (valuation date) only.
This is the ultimate deadline to unsubscribe or enrol for
Abstract
Session requirements.
Objective
Requirements.
Content
Session requirements.

052-1101-AAL Architectural Design V-IX (Part 2) E- 14 credits 16U Lecturers
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Please register (www.mystudies.ethz.ch) only after the internal enrolment for the design classes (see http://www.einschreibung.arch.ethz.ch/design.php)

Project grading at semester end is based on the list of enrolments on 1.11.2022, 24:00 h (valuation date) only. This is the ultimate deadline to unsubscribe or enroll for the studio.

Abstract
Session requirements.
Objective
Requirements.
Content
Session requirements.

Architecture Master - Key for Type

| O  | Compulsory |
| W+ | Eligible for credits and recommended |
| W  | Eligible for credits |
| E- | Recommended, not eligible for credits |
| Z  | Courses outside the curriculum |
| Dr | Suitable for doctorate |

Key for Hours

| V  | lecture |
| G  | lecture with exercise |
| U  | exercise |
| S  | seminar |
| K  | colloquium |
| P  | practical/laboratory course |
| A  | independent project |
| D  | diploma thesis |
| R  | revision course / private study |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Atmospheric and Climate Science Master

Modules

Weather Systems and Atmospheric Dynamics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Wernli, L. Papritz</td>
</tr>
</tbody>
</table>

Abstract

This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Objective

Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

Content

Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes

Dynamics of large-scale atmospheric flow

Literature

- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Prerequisites / notice

Physics I, II, Environmental Fluid Dynamics

Climate Processes and Feedbacks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1235-00L</td>
<td>Cloud Microphysics</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>Z. A. Kanji, N. Shardt, Y. Wang</td>
</tr>
</tbody>
</table>

Abstract

Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

Objective

The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.

Content

see: http://www.iaa.etfzh.ch/edu/courses/master/modules/cloud-microphysics.html
and: https://moodle-app2.let.ethz.ch/course/view.php?id=15424

Lecture notes

This course will be designed as a reading course in 1-2 small groups of 10 students maximum. It will be based on the textbook below. The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth.

Literature


Prerequisites / notice

Target group: Doctoral and Master students in Atmosphere and Climate
**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Analytical Competencies
  - Problem-solving
  - Communication
  - Critical Thinking
  - Self-direction and Self-management

- **Method-specific Competencies**

- **Social Competencies**

- **Personal Competencies**

**701-1251-00L  Land-Climate Dynamics**

*Number of participants limited to 36.*

*The target groups are the following:*
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

*Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.*

**Abstract**

The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

**Objective**

The students can understand the role of land processes and associated feedbacks in the climate system.

**Lecture notes**

Powerpoint slides will be made available

**Prerequisites / notice**

Prerequisites: Introductory lectures in atmospheric and climate science


**►► Atmospheric Composition and Cycles**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1239-00L</td>
<td>Aerosols I: Physical and Chemical Principles</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>M. Gysel Beer, D. Bell, E. Weingartner</td>
</tr>
</tbody>
</table>

**Abstract**

Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

**Objective**

Physical and chemical principles:
- The students...
- know the processes and physical laws of aerosol dynamics.
- understand the thermodynamics of phase equilibria and chemical equilibria.
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:
- The students...
- know the most important chemical and physical measurement instruments.
- understand the underlying chemistry and physics.

Environmental impacts:
- The students...
- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- know the most important climate impacts of atmospheric aerosols.
- are aware of the health impacts of atmospheric aerosols.

**Lecture notes**

Material is distributed during the lecture

**Literature**


**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- **Social Competencies**

- **Personal Competencies**

**701-1233-00L  Stratospheric Chemistry**

| W | 4 credits | 2V+1U | T. Peter, G. Chiodo |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 143 of 2416
### Climate History and Paleoclimatology

**Number** 651-4057-00L  
**Title** Climate History and Paleoclimatology  
**Type** W  
**ECTS** 4 credits  
**Hours** 2G  
**Lecturers** H. Stoll, I. Hernández Almeida, H. Zhang

**Abstract**  
Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

**Objective**  
The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. The student will also acquire a good understanding of the coupling between stratospheric ozone and climate change. Furthermore, they will be able to explain fundamental concepts in stratigraphic chemistry by means of scientific paper presentations.

**Content**  
- Short presentation of thermodynamical and kinetic basics of chemical reactions: bi- and termolecular reactions, photo-dissociation, introduction to the chemical family concept: active species, their source gases and reservoir gases.
- Detailed treatment of the pure oxygen family (odd oxygen) according to the Chapman chemistry. Radical reactions of the oxygen species with nitric oxide, active halogens (chlorine and bromine) and odd hydrogen. Ozone depletion cycles. Methane depletion and ozone production in the lower stratosphere (photo-smog reactions). Heterogeneous chemical kinetics on the background aerosol and its significance for heavy air traffic. Chemistry and dynamics of the ozone hole: Formation of polar stratospheric clouds and chlorine activation.

**Lecture notes**  
Documents are provided in the contact hours.

**Literature**  

**Prerequisites / notice**  
Prerequisites: Basics in physical chemistry are required and an overview equivalent to the bachelor course in atmospheric chemistry (lecture 701-0471-01) is expected.

701-1233-00 V starts in the first week of the semester. The exercises 701-1233-00 U will start only in the 2nd week of the semester.

### Hydrology and Water Cycle

**Number** 701-1251-00L  
**Title** Land-Climate Dynamics  
**Type** W  
**ECTS** 3 credits  
**Hours** 2G  
**Lecturers** S. I. Seneviratne, R. Padron Flasher, P. Sieber

**Abstract**  
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

**Objective**  
The students can understand the role of land processes and associated feedbacks in the climate system.

**Lecture notes**  
Powerpoint slides will be made available

**Prerequisites / notice**  
Prerequisites: Introductory lectures in atmospheric and climate science


Data: 01.11.2022 12:41  
Autumn Semester 2022  
Page 144 of 2416
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on overall goals of this course are given below. Focus is on the theoretical background and idealized concepts.

Introduction
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective
Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

Content
- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes
available (i.e. in English)

Literature
For complementary reading:
- Prerequisites / notice
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

Boundary Layer Meteorology
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts.

Objective
Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

Content
- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes
available (i.e. in English)

Literature
For complementary reading:
- Prerequisites / notice
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

Watershed Modelling
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a seminar-end oral examination (30 mins) on watershed modelling concepts.

Content
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
Literature consists of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).
## Concepts and Theories

### Dynamics of Large-Scale Atmospheric Flow

**Abstract**
This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

**Objective**
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

**Content**
Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

**Lecture notes**
Dynamics of large-scale atmospheric flow

**Literature**
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

### Climate History and Palaeoclimatology

**Abstract**
Climate history and palaeoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

**Objective**
The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

**Content**
The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### European Climate Change

**Abstract**
The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:

- observational datasets, observation and detection of climate change;
- underlying physical processes and feedbacks;
- numerical and statistical approaches;
- currently available projections.

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**Data:** 01.11.2022 12:41  
**Autumn Semester 2022**  
**Page:** 146 of 2416
At the end of this course, participants should:

- understand the key physical processes shaping climate change in Europe;
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
- be familiar with relevant observational and modeling data sets;
- be able to tackle simple climate change questions using available data sets.

Contents:

- global context
- observational data sets, analysis of climate trends and climate variability in Europe
- global and regional climate modeling
- statistical downscaling
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
- projections of European and Alpine climate change

Slides and lecture notes will be made available at http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html

Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

### Atmospheric Composition and Cycles

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0635-01L</td>
<td>Air Pollution Control</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>J. Wang, B. Buchmann</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture provides in the first part an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and their impact on air quality. The second part covers different strategies and techniques for emission reduction. The basic knowledge is deepened by the discussion of specific air pollution problems of today's society.

**Objective**
The students gain general knowledge of the technical processes resulting in air pollution and study the methods used for air pollution control. The students can identify major air pollution sources and understand the methods for measuring pollutants, collecting and analyzing data. The students can suggest and evaluate possible control methods and equipment, design control systems and estimate their efficiency and efforts.

The students know the different strategies of air pollution control and are familiar with their scientific fundamentals. They are able to incorporate goals concerning air quality into their engineering work.

**Content**

**Part 1 Emission, Immission, Transmission**

- physical and chemical processes leading to emission of pollutants
- mass and energy of processes
- Emission measurement techniques and concepts
- quantification of emissions from individual and aggregated sources
- extent and development of the emissions (Switzerland and global)
- propagation and transport of pollutants (transmission)
- meteorological parameters influencing air pollution dispersion
- deterministic and stochastic models, describing air pollution dispersion
- dispersion models (Gaussian model, box model, receptor model)
- measurement concepts for ambient air (immission level)
- extent and development of ambient air mixing ratios
- goal and instrument of air pollution control

**Part 2 Air Pollution Control Technologies**
The reduction of the formation of pollutants is done by modifying the processes (process-integrated measures) and by different engineering operations for the cleaning of waste gas (downstream pollution control). It will be demonstrated, that the variety of these procedures can be traced back to the application of a few basic physical and chemical principles.

**Procedures for the removal of particles** (inertial separator, filtration, electrostatic precipitators, scrubbers) with their different mechanisms (field forces, impaction and diffusion processes) and the modelling of these mechanisms.

**Procedures for the removal of gaseous pollutants** and the description of the driving forces involved, as well as the equilibrium and the kinetics of the relevant processes (absorption, adsorption as well as thermal, catalytic and biological conversions).

Discussion of the technical possibilities to solve the actual air pollution problems.

**Lecture notes**

- Brigitte Buchmann, Air pollution control, Part I
- Jing Wang, Air pollution control, Part II
- Lecture slides and exercises

**Literature**

List of literature included in script

**Prerequisites / notice**

College lectures on basic physics, chemistry and mathematics.

Language of instruction: In German or in English.
Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

701-1235-00L  Cloud Microphysics  W  4 credits  2V+1U  Z. A. Kanji, N. Shardt, Y. Wang

Abstract
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

Objective
The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.

Content
see: http://www.iac.ehtz.ch/edu/courses/master/modules/cloud-microphysics.html
and: https://moodle-app2.let.ehtz.ch/course/view.php?id=15424

Lecture notes
This course will be designed as a reading course in 1-2 small groups of 10 students maximum. It will be based on the textbook below. The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth.

Literature
Lamb and Verlinde: PHYSICS AND CHEMISTRY OF CLOUDS, Cambridge University Press, 2011

Prerequisites / notice
Target group: Doctoral and Master students in Atmosphere and Climate

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Method-specific Competencies
Analytical Competencies
Social Competencies
Communication
Personal Competencies
Adaptability and Flexibility

651-4053-05L  Boundary Layer Meteorology  W  4 credits  3G  M. Rotach, P. Calanca

Abstract
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface, Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective
Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Content
- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes
available (i.e. in English)

Literature

Prerequisites / notice
Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science
Two courses are offered in Autumn Semester at University of Berne. ETH courses are only offered in Spring Semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4041-00L</td>
<td>Sedimentology I: Physical Processes and Sedimentary Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti</td>
</tr>
</tbody>
</table>

Abstract
Sediments preserved a record of past landscapes. This course focuses on understanding the processes that modify sedimentary landscapes with time and how we can read this changes in the sedimentary record.

Objective
The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.

Content
Details on the program will be handed out during the first lecture.

Literature
The sedimentary record of sea-level change
Angela Coe, the Open University. Cambridge University Press

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

<table>
<thead>
<tr>
<th>Number</th>
<th>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</th>
</tr>
</thead>
</table>

Prerequisite: Successful completion of the MSc-course "Sedimentology I" (651-4041-00L).

Abstract
The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

Objective
- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

Content
- carbonates, chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine sediments through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

Lecture notes
no script. scientific articles will be distributed during the course

Literature
We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

<table>
<thead>
<tr>
<th>Number</th>
<th>Quaternary Dating Methods</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>I. Hajdas, M. Christl, S. Ivy Ochs</th>
</tr>
</thead>
</table>

Abstract
Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.

Objective
Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

At the end of the course students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. be able to calculate an age based on data of the six methods studied.
3. choose which dating method (or combination of methods) is suitable for a certain field problem.
4. critically read and evaluate the application of dating methods in scientific publications.

Content
1. Introduction: Time scales for the Quaternary, Isotopes and decay
2. Radiocarbon dating: principles and applications
3.Cosmogenic nuclides: 3He,10Be, 14C, 21Ne, 26Cl, 36Cl
4. U-series disequilibrium dating
5. Luminescence dating
6. Introduction to incremental: varve counting, dendrochronology and ice cores chronologies
7. Cs-137 and Pb-210 (soil, sediments, ice core)
8. Summary and comparison of results from several dating methods at specific sites

Prerequisites / notice
Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.

Visit to Limno Lab and sampling a sediment core
Optional (individual): 1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggeregiberg

Required: attending the lecture, visiting laboratories, handing back solutions for problem sets (Exercises)

Hydrology and Water Cycle

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4023-00L</td>
<td>Groundwater</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>X.-Z. Kong, B. Marti</td>
</tr>
</tbody>
</table>

Abstract
The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, formulating, and solving groundwater flow and solute transport problems.

Objective
a) Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions.

b) Students are able to formulate simple, practical groundwater flow and solute transport problems.

c) Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems.
Content

1. Introduction to groundwater problems. Concepts to quantify properties of aquifers.
2. Flow equation. The generalised Darcy law.
3. The water balance equation and basic concepts of poroelasticity.
5. Analytical solutions to flow problems
6. Finite difference scheme solution for simple flow problems.
10. Analytical solutions to transport problems.
11. Fractured and karst aquifers.
12. The unsaturated zone and capillary pressure.
13. Examples of applied hydrogeology from Switzerland and around the world. (Given by Dr. Beatrice Marti from Hydrosolutions Ltd.)

Lecture notes

Handouts of slides.

Literature

de Marsily G., Quantitative Hydrogeology, Academic Press, 1986

102-0287-00L River Basin Erosion W 3 credits 2G P. Molnar

Abstract

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Objective

The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

Content

The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes

There is no script.

Literature

The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice

Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

701-0535-00L Environmental Soil Physics/Vadose Zone Hydrology W 3 credits 2V+1U A. Carminati, P. U. Lehmann Grunder

Abstract

The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

Objective

Students are able to:
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils
The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be

Z. U. Siegfried

Seminar in Hydrology

Slides and reading materials will be made available via Moodle.

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Week 8 (November 09): Numerical solution of Richards equation – Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)

Week 9 (November 16): Solute and gas transport in soils - Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 10 (November 23): Conductivity and resistance of soils – differences and similarities of hydraulic, electrical, thermal conductivities; Buckingham-Darcy, Fourier, and Archie’s law; pore scale characteristics and effective conductivities; soil thermal properties; steady state and non-steady heat flow

Week 11 (November 30): Energy balance and land atmosphere interactions - Radiation and energy balance; evapotranspiration, potential and actual evaporation, definitions and estimation; evaporation stages and characteristic length

Week 12 (December 07): Root water uptake and transpiration – Mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance

Week 13 (December 14): Summary, questions, old exam

Week 14 (December 21): Written Semester-end exam

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

<table>
<thead>
<tr>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Week 1 (September 21): Introduction, content, structure of the course, objectives, bibliography, grading and evaluation; soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density.</td>
</tr>
<tr>
<td>Week 2 (September 28): Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation; surface tension; Young-Laplace equation; capillary rise; contact angle.</td>
</tr>
<tr>
<td>Week 3 (October 05): Friction and laminar flow; Hagen-Poiseille’s law; Washburn equation; numerical lab (including report)</td>
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<tr>
<td>Week 4 (October 12): Soil water content; soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point.</td>
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<tr>
<td>Week 5 (October 19): Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; Demo lab (including report)</td>
</tr>
<tr>
<td>Week 6 (October 26): Saturated water flow in soils - Laminar flow in tubes (Poiseuille’s Law); Darcy’s Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman); effective conductivity; unsaturated hydraulic conductivity; Buckingham law.</td>
</tr>
<tr>
<td>Week 7 (November 02): Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow</td>
</tr>
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<td>Week 8 (November 09): Numerical solution of Richards equation – Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)</td>
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<thead>
<tr>
<th>Literature</th>
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<tbody>
<tr>
<td>860-0012-00L Seminar in Hydrology Z 0 credits 1S P. Burlando, J. W. Kirchner, C. Schär, M. Schirmer, S. I. Seneviratne, M. Stähli, C. H. Stamm, University lecturers</td>
</tr>
</tbody>
</table>

651-2915-00L Cooperation and Conflict Over International Water Resources W 3 credits 2G T. Bernauer, T. U. Siegfried

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

Abstract

This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Objective

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

20. Sep Global water challenges
27. Sep Nuts and bolts of hydrological modeling and what such models can tell us
04. Oct Nuts and bolts of hydrological modeling and what such models can tell us
11. Oct Water pollution and its mitigation
18. Oct Key challenges in international river systems
25. Oct Key challenges in international river systems
01. Nov Case study 1: Yarmuk
08. Nov Case study 2: Mekong
15. Nov Case study 3: Colorado
22. Nov Case study 4: Nile
29. Nov Case study 5: Central Asia
06. Dec Wrap up: what we can learn from these case studies
13. Dec Exam
20. Dec No class

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Lecture notes

Slides and reading materials will be made available via Moodle.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 151 of 2416
The course is open to Master and doctoral students from any area of ETH. Limited to 40 students. Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.

### Prerequisites

The definition of prerequisites is part of the admission procedure for the master studies. You are informed by the admission office as to what courses of the section «prerequisites» you have to catch up with. You are accredited for these courses in the electives block of the master studies.

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<tr>
<th>Number</th>
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<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>701-0471-01L</td>
<td>Atmospheric Chemistry</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Ammann, T. Peter</td>
</tr>
<tr>
<td>701-0473-00L</td>
<td>Weather Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. A. Sprenger, F. Scholder-Aemisegger</td>
</tr>
<tr>
<td>701-0475-00L</td>
<td>Atmospheric Physics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>F. Mahrt</td>
</tr>
</tbody>
</table>

### Literature

- John M. Wallace and Peter V. Hobbs, Academic Press
- From the Microscale to Climate, Cambridge Univ. Press, 391 pp., 2016.
Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

### Prerequisites / notice
For certain capers we'll use the concept of "flipped classroom" ([en.wikipedia.org/wiki/Flipped_classroom](http://en.wikipedia.org/wiki/Flipped_classroom)), which we introduce at the beginning.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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<td>Self-direction and Self-management</td>
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</table>

### 701-0461-00L Numerical Methods in Environmental Physics

#### Abstract
This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.

#### Objective
Ability to develop simple numerical schemes and to implement these schemes using the programming language Python. Ability to critically use more complex numerical models.

#### Content
Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration schemes, non-linearity, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-section of Environmental Science.

Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not necessary, a Phython introduction is provided). Example programs and graphics tools are supplied.

#### Lecture notes

#### Literature
List of literature is provided.

### Additional Electives ETH

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4273-00L</td>
<td>Numerical Modelling in Fortran</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Tackley</td>
</tr>
<tr>
<td>701-1257-00L</td>
<td>European Climate Change</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>C. Schär, C. Zeman</td>
</tr>
<tr>
<td>701-1281-00L</td>
<td>Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS)</td>
<td>W</td>
<td>3</td>
<td>6A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Prerequisites / notice**

Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

Students are allowed to enroll in both courses 701-1280-00L & 701-1281-00L Self-learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.

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**Data: 01.11.2022 12:41**

**Autumn Semester 2022**

**Page 153 of 2416**
This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:
- atmospheric chemistry
- atmospheric dynamics
- atmospheric physics
- climate modeling
- climate physics
- land-climate dynamics
- atmospheric circulation
- paleoclimate
- ocean biogeochemical dynamics

**Objective**

The learning goals of this course are threefold:
1. obtain novel insight into an advanced scientific topic,
2. train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and
3. gain experience in the scientific interaction with experts.

The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

**Content**

The course has the following elements:

- **Week 1:** Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
- **Week 2:** General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University: https://www.coursera.org/learn/sciwrite?action=enroll
- **Weeks 6 and 9:** Meetings with supervisor to clarify scientific questions
- **Week 12:** Hand-in of written summary (4 pages maximum)
- **Week 14:** Supervisor provides written feedback to the summary document
- **Week 16:** Oral exam about the scientific topic

**Literature**

Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.

**Prerequisites / notice**

Prerequisites depend on the chosen field and include successful completion of the listed lecture courses:
- atmospheric dynamics: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- atmospheric chemistry: “Stratospheric Chemistry” (701-1233-00L) or “Tropospheric Chemistry” (701-1234-00L) or “Aerosols I” (402-0572-00L)
- atmospheric physics: “Atmospheric Physics” (701-0475-00L)
- climate physics: “Klimasysteme” (701-0412-00L) or equivalent
- land-climate dynamics: “Land-climate dynamics” (701-1251-00L)
- climate modeling: “Numerical modeling of weather and climate” (701-1221-00L) (parallel attendance possible)
- paleoclimate: “Climate History and Paleoclimate” (651-4057-00L)
- ocean biogeochemical dynamics: “Global Biogeochemical Cycles and Climate” (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.
- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

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**Minors**

**Minor in Physical Glaciology**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
101-0289-00L | Applied Glaciology | W | 4 credits | 2G | D. Farinotti, A. Bauder, M. Werder

**Abstract**

The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

**Objective**

The objectives of the courses are to:
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

**Content**

The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Glacial hydrology
- Glacial hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

**Lecture notes**

Digital lecture handouts will be distributed prior to each class.

**Literature**

Links to relevant literature will be provided during the classes.

**Prerequisites / notice**

Completed BSc studies. Basic knowledge in computer scripting in any language (e.g. Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.
Fostered competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies

- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies

- Communication not assessed
- Cooperation and Teamwork assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies

- Adaptability and Flexibility not assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management assessed

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651-4101-00L   Physics of Glaciers   W   3 credits   3G   M. Lüthi, F. T. Walter, M. Werder

Abstract
Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

Objective
After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

Content
The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Lecture notes
Will be provided on Moodle

Literature
A list of relevant literature is available on Moodle

Prerequisites / notice
High-school mathematics and physics knowledge required.

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651-4077-00L   Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)   W   3 credits   1V   University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO815

Mind the enrolment deadlines at UZH:

Abstract
Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

Objective
Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.

Content
Erosion and sedimentation by glaciers as a function of topography, englacial temperature, sediment balance, sliding and melt water runoff. Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).

Lecture notes
Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

Literature references in skript

Prerequisites / notice
Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes

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651-1581-00L   Seminar in Glaciology   W   3 credits   2S   A. Bauder, M. Jacquemart

Abstract
Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.

Objective
In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

Content
Selected topics of scientific research in Glaciology

Lecture notes
Copies/pdf of scientific papers will be distributed during the course (moodle interface)

Prerequisites / notice
Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

---
Abstract
The course introduces the scientific concepts and typical applications of tracers in biogeochemistry. The course covers stable and radioactive isotopes, geochemical tracers and biomarkers and their application in biogeochemical processes as well as regional and global cycles. The course provides essential theoretical background for the lab course "Isotopic and Organic Tracers Laboratory".

Objective
The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and decay modes of relevant radiogenic isotopes. They discover the spectrum of possible geochemical tracers and biomarkers, their potential and limitations and get familiar with important applications.

Content
- Geogenic and cosmogenic radionuclides (sources, decay chains);
- Stable isotopes in biogeochemistry (natural abundance, fractionation);
- Geochemical tracers for processes such as erosion, productivity, redox fronts; biomarkers for specific microbial processes.

Lecture notes
Handouts will be provided for every chapter.

Literature
A list of relevant books and papers will be provided.

Prerequisites / notice
Students should have a basic knowledge of biogeochemical processes (BSc course on Biogeochemical processes in aquatic systems or equivalent).

Abstract
The course addresses the biogeochemical classification and behavior of trace elements, including key processes driving the cycling of important trace elements in aquatic and terrestrial environments and the coupling of abiotic and biotic transformation processes of trace elements. Examples of the role of trace elements in natural or engineered systems will be presented and discussed in the course.

Objective
The students are familiar with the chemical characteristics, the environmental behavior and fate, and the biogeochemical reactivity of different groups of trace elements. They are able to apply their knowledge on the interaction of trace elements with geosphere components and on abiotic and biotic transformation processes of trace elements to discuss and evaluate the behavior and impact of trace elements in aquatic and terrestrial systems.

Content
- Definition, importance and biogeochemical classification of trace elements.
- Key biogeochemical processes controlling the cycling of different trace elements (base metals, redox-sensitive and chalcophile elements, volatile trace elements) in natural and engineered environments.
- Abiotic and biotic processes that determine the environmental fate and impact of selected trace elements.

Lecture notes
Selected handouts (lecture notes, literature, exercises) will be distributed during the course.

Prerequisites / notice
Students are expected to be familiar with the basic concepts of aquatic and soil chemistry covered in the respective classes at the bachelor level (soil mineralogy, soil organic matter, acid-base and redox reactions, complexation and sorption reactions, precipitation/dissolution reactions, thermodynamics, kinetics, carbonate buffer system).

The lecture 701-1315-00L Biogeochemistry of Trace Elements is a prerequisite for attending the laboratory course 701-1331-00L Trace Elements Laboratory, or students must be concurrently enrolled in 701-1315-00L Biogeochemistry of Trace Elements in the same semester.

Abstract
Future climate change can only kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

Objective
The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

Content
From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Lecture notes
None

Literature
Will be identified based on the chosen topic.

Prerequisites / notice
Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.
**701-0015-00L**

**Title:** Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement

**Type:** W

**ECTS:** 2 credits

**Hours:** 2S

**Lecturers:** B. Vienni-Baptista, C. E. Pohl, M. Stauffacher

**Abstract:**
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

**Objective:**
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

**Content:**
The seminar covers the following topics:
1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

**Literature:**
Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

**Prerequisites / notice:**
Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

**Fostered competencies:**
- Subject-specific Competencies: Concepts and Theories - not assessed
- Method-specific Competencies: Problem-solving - not assessed
- Social Competencies: Cooperation and Teamwork - not assessed
- Personal Competencies: Critical Thinking - not assessed

**701-1551-00L**

**Title:** Sustainability Assessment

**Type:** W

**ECTS:** 3 credits

**Hours:** 2G

**Lecturers:** P. Krüttli, D. Nef

**Abstract:**
The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.

**Objective:**
At the end of the course, students:
- know core concepts of sustainable development, main features of social justice in the context of sustainability, a selection of methodologies for the assessment of sustainable development
- have a deepened understanding of the challenges of trade-offs between the different dimensions of sustainable development and their respective impacts on individual and societal decision-making
- have a broadened understanding of the challenges of trade-offs between the different dimensions of sustainable development and their respective impacts on individual and societal decision-making

**Content:**
The course is structured as follows:
- overview of rationale, objectives, concepts and origins of sustainable development (approx. 15%)
- overview of the concept of social justice as guiding principle of the social dimension of sustainability (approx. 20%)
- analysis of a selection of concepts and methodologies to assess sustainable development in a variety of contexts (approx. 65%)

**Lecture notes / Literature:**
Handouts are provided
Selected scientific articles and book-chapters

**Prerequisites / notice:**
Students of this course may also be interested in the course transdisciplinary case study (tcDS) in the Spring semester (701-1502-00L)

**Fostered competencies:**
- Subject-specific Competencies: Concepts and Theories assessed
- Social Competencies: Communication not assessed
- Personal Competencies: Creative Thinking not assessed

**860-0012-00L**

**Title:** Cooperation and Conflict Over International Water Resources

**Type:** W

**ECTS:** 3 credits

**Hours:** 2G

**Lecturers:** T. Bernauer, T. U. Siegfried

**Abstract:**
This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

**Objective:**
Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.
Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization. Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, D. Reichelt

Slides and reading materials will be made available via Moodle.

1. Knowlege on the worldwide liberalisation of electricity markets, pan-european power trading and the role of power exchanges. Understand Power Market I - Portfolio and Risk Management

G. A. Koeppel

Lecture Notes containing copies of the presented slides.

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be

E. I. M. Casati

W

Energy and Climate Design I

A. Steinfeld

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering

A. Schlüter

Type

ECTS

Hours

Lecturers

227-0731-00L

Power Market I - Portfolio and Risk Management

W

6 credits

4G

D. Reichelt, G. A. Koeppel

Abstract

Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

Objective


Content

1. Pan-European power market and trading

1.1. Power trading

1.2. Development of the European power markets

1.3. Energy economics

1.4. Spot and OTC trading

1.5. European energy exchange EEX

2. Market model

2.1. Market place and organisation

2.2. Balance groups / balancing energy

2.3. Ancillary services

2.4. Market for ancillary services

2.5. Cross-border trading

2.6. Capacity auctions

3. Portfolio and Risk management

3.1. Portfolio management 1 (introduction)

3.2. Forward and futures contracts

3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)

3.4. Risk management 2 (PaR)

3.5. Contract valuation (HPFC)

3.6. Portfolio management 2

2.8. Risk Management 3 (enterprise wide)

4. Energy & Finance I

4.1. Options 1 basics

4.2. Options 2 hedging with options

4.3. Introduction to derivatives (swaps, cap, floor, collar)

4.4. Financial modelling of physical assets

4.5. Trading and hydro power

4.6. Incentive regulation

Lecture notes

Handouts of the lecture

Prerequisites / notice

1 excursion per semester, 2 case studies, guest speakers for specific topics.

Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

151-0209-00L

Renewable Energy Technologies

W

4 credits

3G

A. Steinfeld, E. I. M. Casati

Abstract

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering

Objective

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture notes

Lecture Notes containing copies of the presented slides.

Prerequisites / notice

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

052-0609-00L

Energy and Climate Design I

W

2 credits

2G

A. Schlüter
Abstract
This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

Objective
At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=11917). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

Content
Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:

1. Local potentials
2. Demand
3. Supply

Lecture notes
The slides of the lecture serve as lecture notes and are available as download.

Literature
A list of relevant literature is available at the chair.

Prerequisites / notice
This course can only be taken if Energy and Climate Design II is taken in the following semester, as the group work is connected and extends throughout the year.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>O</th>
<th>Methods and Technologies</th>
<th>1 credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analytical Competencies</td>
<td></td>
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<tr>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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</table>

Social Competencies

| Communication               |       |                          |          |
| Cooperation and Teamwork    |       |                          |          |
| Sensitivity to Diversity    |       |                          |          |

Personal Competencies

| Adaptability and Flexibility|       |                          |          |
| Creative Thinking           |       |                          |          |
| Critical Thinking           |       |                          |          |
| Integrity and Work Ethics   |       |                          |          |
| Self-direction and Self-management | | | |

Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4095-01L</td>
<td>Colloquium Atmosphere and Climate 1</td>
<td>O</td>
<td>1 credit</td>
<td>1K</td>
<td>H. Joos, H. Wernli, D. N. Bresch, D. Domeisen, N. Gruber, R. Knutti, U. Lohmann, T. Peter, C. Schär, S. Schemm, S. I. Seneviratne, M. Wild</td>
</tr>
</tbody>
</table>

Abstract
The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

Objective
The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

Content
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Prerequisites / notice
Attendance is mandatory.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 159 of 2416
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

### Objective
Apply scientific project management techniques to your master project, practice the presentation of scientific results and how to chair other students' presentations and lead the discussion.

### Content
In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

### Prerequisites / notice
Attendance is mandatory.

#### Laboratory and Field Courses

The course in the category «lab and field work» are only offered in spring semester.

#### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4275-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
<tr>
<td></td>
<td>Only students who fulfill the following criteria are allowed to begin with their master thesis: a. successful completion of the bachelor programme; b. fulfilling of any additional requirements necessary to gain admission to the master programme.</td>
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<td>The master thesis is supervised by a professor of the D-ERDW or of the Institute for Atmosphere and Climate (IAC, D-USYS), a professor who teaches in the module subjects or a senior scientist who is on the list of &quot;competent leaders of master theses&quot; of the D-ERDW or of the D-USYS (associated with the IAC).</td>
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</table>

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0412-AAL</td>
<td>Climate Systems</td>
<td>E-</td>
<td>3</td>
<td>6R</td>
<td>S. I. Seneviratne</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td></td>
<td>Introduction of the most important components of the climate systems and their interactions.</td>
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<tr>
<td></td>
<td>Students have a basic understanding of the global energy balance, radiation budget, boundary, layer, atmosphere, ocean, biosphere, land-surface coupling, cryosphere, carbon cycle, climate variability, climate of the past and anthropogenic climate change, and they are able to apply this to solve simple quantitative problems and answer qualitative questions.</td>
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<td></td>
<td>Copies of the slides are provided in electronic form.</td>
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<tr>
<td></td>
<td>Teaching: Reto Knutti, several keynotes to special topics by other professors</td>
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<tr>
<td></td>
<td>Course taught in german, slides in english</td>
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<table>
<thead>
<tr>
<th>701-0471-AAL</th>
<th>Atmospheric Chemistry</th>
<th>E-</th>
<th>3</th>
<th>6R</th>
<th>M. Ammann, T. Peter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
<td></td>
<td>This is a self-study course targeted at Master students who did not follow the bachelor course &quot;atmospheric chemistry&quot; or similar. The course provides a general introduction into atmospheric chemistry.</td>
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<td></td>
<td>The learning target of this lecture is a general overview on the most important processes of atmospheric chemistry and the various problems of the anthropogenic change in the structure of Earth's atmosphere.</td>
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</tbody>
</table>
Content

- Origin and properties of the atmosphere: structure, large scale dynamics, UV radiation
- Thermodynamics and kinetics of gas phase reactions: enthalpy and free energy of reactions, rate laws, mechanisms of bimolecular and
termolecular reactions.
- Tropospheric photochemistry: Photochemistry reactions, photochemical O3 formation, role and budget of HOx, dry and wet deposition
- Aerosols and clouds: chemical properties, primary and secondary aerosol sources, phase transfer kinetics, solubility and hygroscopicity,
N2O5 chemistry, SO2 oxidation, secondary organic aerosols
- Air quality: role of planetary boundary layer, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Stratospheric chemistry: Chapman cycle, Brewer-Dobson circulation, catalytic ozone destruction cycles, polar ozone hole, Montreal
protocol
- Global aspects: global budgets of ozone, methane, CO and NOx, air quality - climate interactions

Prerequisites / notice

Basic courses in chemistry and physics are expected

701-0475-AAL  Atmospheric Physics  E-  3 credits  6R  F. Mahrt

- Enrolment ONLY for MSc students with a decree declaring
  this course unit as an additional admission requirement.

Abstract

This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, thermodynamics, aerosol
physics, radiation as well as the impact of aerosols and clouds on climate and artificial weather modification.

Objective

- to explain the mechanisms of cloud and precipitation formation using knowledge of humidity processes and thermodynamics.
- to evaluate the significance of clouds and aerosol particles for climate and artificial weather modification.

Content

- Moist processes/thermodynamics; aerosol physics; cloud formation; precipitation processes, storms; importance of aerosols and clouds for
  climate and weather modification, clouds and precipitation

Lecture notes

Powerpoint slides and script will be made available

Literature


701-0473-AAL  Weather Systems  E-  3 credits  6R  M. A. Sprenger, F. Scholder-Aemisegger

- Enrolment ONLY for MSc students with a decree declaring
  this course unit as an additional admission requirement.

Abstract

The students learn about the dynamical features of the Earth's atmosphere. They interpret satellite imagery and learn about basic concepts
in dynamical meteorology. The global circulation is briefly discussed, before introducing the Eulerian and the Lagrangian perspective,
which are used to study air streams in extratropical cyclones and to investigate basic aspects in mountain meteorology.

Objective

- to explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- to discuss the role of moist adiabatic processes for weather systems and why stable water isotopes are useful in this context

Content

- Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-
  atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; potential vorticity, Alpine dynamics (storms,
  orographic wind); planetary boundary layer

Lecture notes

Lecture notes and slides

Literature

Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

701-0461-AAL  Numerical Methods in Environmental Physics  E-  3 credits  6R  C. Schär

- Enrolment ONLY for MSc students with a decree declaring
  this course unit as an additional admission requirement.

Abstract

This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of
Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential
equations, as well as exercises aimed at the realization of simple models using the computer language Python.

Objective

- Ability to develop simple numerical schemes and to implement these schemes using the programming language Python. Ability to critically
  use more complex numerical models.
- Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration
  schemes, non-linearity, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-
  section of Environmental Science.
- Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not
  necessary, a Python introduction is provided). Example programs and graphics tools are supplied.

Literature

List of literature is provided.

701-0106-AAL  Mathematics V: Applied Deepening of Mathematics I - III  E-  3 credits  6R  M. A. Sprenger

- Enrolment ONLY for MSc students with a decree declaring
  this course unit as an additional admission requirement.

Abstract

Selected mathematical topics are presented for later use in more specialised lectures. Part of the topics were already discussed in the
lectures Mathematics I-III. Here, they should be shortly recapitulated and most importantly applied to practical problems. If necessary, new
mathematical concepts and methods will be introduced in order to solve challenging and inspiring problems from practice.

Objective

- The aim of this lecture is to prepare the students for the more specialised lectures. They should become more familiar with the
  mathematical background, the mathematical concepts and most of all with their application and interpretation.

Content

- Practical examples from the following areas will be discussed: ordinary differential equations; eigenvalue problems from linear algebra;
  systems of linear and nonlinear differential equations; partial differential equations (diffusion, transport, waves).

701-0071-AAL  Mathematics III: Systems Analysis  E-  4 credits  9R  R. Knutti, H. Wernli
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance.
Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content
Introduction to principles of models; one-dimensional linear box models; multi-dimensional linear box models; nonlinear box models; models in space and time

Lecture notes
Teaching material: book (see literature).

Literature


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**Atmospheric and Climate Science Master - Key for Type**

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<thead>
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<th>W+</th>
<th>Eligible for credits and recommended</th>
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<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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**Key for Hours**

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<thead>
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<td>revision course / private study</td>
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**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Educational Science for Teaching Diploma and TC

These are the general course offerings of the programmes Teaching Diploma (TD) - categories Educational Science and Compulsory Elective Courses - and Teaching Certificate (TC) - category Educational Science.

<table>
<thead>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 163 of 2416
Abstract

Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective

- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

851-0242-11L Gender Issues In Education and STEM ■
Number of participants limited to 30.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract

In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM); Common perspectives, controversies and empirical evidence will be discussed.

Objective

- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues.
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

851-0228-00L Formation of Knowledge in STEM Fields in Primary and Secondary School ■

Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in the course 851-0240-00L “Human Learning (EW 1)”.

Abstract

The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

Objective

Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

Content

Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

851-0240-00L Human Learning (EW1)

This lecture is only apt for students who intend to enrol in the programs “Teaching Diploma” or “Teaching Certificate”. It is about learning in childhood and adolescence.

Abstract

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content

The following learning outcomes are targeted: Themen: Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzentwicklung unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen.


Lecture notes

Folienden werden zur Verfügung gestellt.

Literature

4) E.Stern

Prerequisites / notice

This lecture is only apt for students who intend to enrol in the programs “Lehrdiplom” or “Didaktisches Zertifikat”. It is about learning in childhood and adolescence.
851-0238-01L  Support and Diagnosis of Knowledge Acquisition Processes (EW3)  O  3 credits  3S  C. M. Thurn, S. Daguati, P. Edelsbrunner
Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the "Teaching Diploma".

Prerequisites: successful participation in 851-0240-00L "Human Learning (EW1)"

Abstract
In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

Objective
The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

851-0242-01L  Coping with Psychosocial Demands of Teaching (EW4)  O  3 credits  3S  S. Peteranderl-Rüschoff, S. Maurer
Enrolment possible with Teaching Diploma matriculation, except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW4.

Abstract
Students learn and practice techniques and skills for coping with psychosocial demands of teaching.

Objective
Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.
1. They know the basic rules of negotiation and conflict management (e.g., mediation) and can apply them in the school context (e.g., conversations with parents).
2. They can apply diverse techniques of classroom management (e.g., prevention of disciplinary problems in the classroom) and know relevant authorities for further information (e.g., legal conditions; crisis intervention).
3. They know stress coping strategies to prevent burnout (e.g., psychosocial support) and are familiar with relevant institutions.

Content
Major themes:
- counseling and counselling techniques
- conflict management and mediation
- classroom management
- supporting students in a psychological crisis
- preventing stress and burnout

Forms of learning
Theoretical foundations will be taught in workshops which contain different means of activation and interaction such as group work, panel discussions, and individual work. Subsequently, this knowledge will be transferred and applied in different school-relevant situations by means of role plays, discussing of cases and video sequences, as well as reflections of practical experiences.

Lectures
Students who intend to enrol in the "Teaching Diploma" will participate in small-group sessions will be discussed how insights from learning research can inform classroom practice.

Literature
Slides of the lecturer's presentations, supplementary materials, and materials for further reading are made available on Moodle.

Prerequisites / note
Verschiedenen Grundlagen- und Anwendungstexte werden den Studierenden zur Verfügung gestellt.

The successful completion of ALL modules relevant for the teacher's diploma is required for participation in this course.

Abstract
The students have to read the book "Lernwirksam unterrichten" from Felten/Stern and they have to answer questions. In individual or small-group sessions will be discussed how insights from learning research can inform classroom practice.

Objective
The focus of all classes on educational psychology is on scientific insights which help to reflect on instructional learning. In order to become professionals, teachers have to better understand students' behavior and achievement and thereby become aware of their scope of classroom practice. Students get a final opportunity to ask questions about psychological learning research.

Literature
Der erfolgreiche Abschluss von EW1 und EW2 stellt eine wünschenswerte, jedoch nicht obligatorische Voraussetzung dar.

851-0240-15L  Designing Educational Environments in Physical Education (EW2 Sport)  O  4 credits  2S  H. Gubelmann, R. Scharpf
Compulsory course requirements for EW2 Sport: This course is required to be taken prior to EW4 Sport "Outdoor Education: Concepts and Practice" (851-0242-02L)

Abstract
Students learn principles of teaching beyond classroom and regular PE-Lessons:
- Planning and organizing camps and events
- Teaching the "Ergänzungsfach Sport"
- Long-term-curricula in PE

As a practical part students design the Outdoor event in EW4 of the following term.

Objective
Students know
- How to plan events and camps
- To assess curricula critically and to use them properly
- How to combine theoretical and practical issues in the ‘Ergänzungsfach’

Content
1. LV Semestereinführung
2. LV Planung Outdoor-Weekend
3. LV Auswertung Outdoor-Event
4. LV Planung Event
5. LV Event-Präsentationen / Schlussveranstaltung

Prerequisites / notice
EW2 is compulsory requirement for EW4 Sport

851-0240-19L  Effective Learning Environments (EW 5)  W  1 credit  E. Stern
The successful completion of ALL modules relevant for the teacher's diploma is required for participation in this course.

Abstract
The focus of all classes on educational psychology is on scientific insights which help to reflect on instructional learning. In order to become professionals, teachers have to better understand students' behavior and achievement and thereby become aware of their scope of classroom practice. Students get a final opportunity to ask questions about psychological learning research.

Literature
Buch "Lernwirksam unterrichten" (Felten/Stern)

Prerequisites / notice
Detailed information: http://www.ifvll.ethz.ch/studium/lehre/ew-5.html

851-0242-07L  Human Intelligence  W  1 credit  1S  E. Stern
Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Number of participants limited to 30.

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human
Cognitively Activating Instructions in MINT Subjects ▶ W 2 credits 2S R. Schumacher

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Abstract
This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

Using Outdoor Education ▶ W 1 credit 1S R. Schumacher, P. Faller

Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.

Abstract
In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Objective
Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Content
Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

Research Methods in Educational Science ▶ W 1 credit 2S C. M. Thurn, T. Braas, P. Edelsbrunner

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract
In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

Gender Issues In Education and STEM ◄ W 2 credits 2S M. Berkowitz Biran, T. Braas, C. M. Thurn

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract
In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Objective
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives
- To integrate this knowledge with teacher's work.

Content
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Supervising and Assessing Matura Theses ▶ W 1 credit 1V J. Maue

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: successful participation in 851-0240-00L "Human Learning (EW1)".

Abstract
This course prepares prospective teachers to supervising and assessing scientific projects at upper secondary school level, particularly Matura theses in STEM subjects at Gymnasium.

Objective
1. Assessing the adequacy of Matura thesis topics and defining the scope of a project.
2. Determining and promoting a successful work process.
3. Devising and applying criteria for assessing process, product and presentation of a Matura thesis.
Prerequisites / notice

Focus on STEM subjects (biology, chemistry, computer science, mathematics, and physics) with no explicit discussion of geography or physical education.

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<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.</td>
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<td>(&quot;Registering for studies at more than one university, Teaching Diploma&quot;, Philosophische Fakultät)</td>
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</table>

Abstract

In this course, options for implementing the specifications in the framework curriculum for the vocational baccalaureate are developed and discussed, e.g. guiding principles of BM teaching, difficulties and challenges of interdisciplinary work. The module is designed for teachers at vocational baccalaureate schools and vocational schools of all disciplines.

Objective

- Students will be able to select subject content in their lessons based on vocational pedagogy, implement vocational pedagogical requirements for lesson design, incorporate interdisciplinary and cross-curricular approaches.
- Students are familiar with various forms and procedures of performance assessment and feedback as well as lesson design. They are able to implement them, taking into account the different contexts in which young people live and work.
- Students are familiar with the content and significance of basic principles such as the vocational baccalaureate ordinance or school curricula and concepts such as sustainability, lifelong learning or error culture. They can use these aspects for school and teaching development and work cooperatively within the college.

Prerequisites / notice

Die Lehrveranstaltung ist seit September 2008 vom Bundesamt für Berufsbildung und Technologie akkreditiert.

Objective
- Students are familiar with a variety of approaches in the areas of individual support, internal differentiation, learning and problem-solving skills as well as constructive error and criticism culture. They are able to use them to promote learning.
- Students are aware of age- and development-typical problems of learners in education, can address them appropriately and involve counseling services and legal representation of young people appropriately.
- Students are able to relate their instructions to the students' learning experiences in professional practice and to their various life and work contexts, and to incorporate them as a starting point for school-based and lifelong learning processes.
- Students can describe and explain the experience and behaviour of adolescents at school and the world of work from different perspectives.

Content
- Positionierung des Berufsfachschulunterrichts innerhalb des dualen (trialen) Systems.
- Berufsmaturität: Entwicklung von Kernkompetenzen für die Wirtschaft?
- "Verakademisierung" der Berufsbildung?
- Lernenden-Porträt: Die Umwelten des Berufsschulunterrichts - Entwicklungschancen und Problembereiche im Zusammenhang mit der Ausbildungssituation.
- Sozialisations- und Lernprozesse im beruflichen Umfeld / Führungsverständnisse im Umgang mit Jugendlichen an Berufsfachschulen.
- Konfliktmanagement I: Wahrnehmungsinstrumente und Interventionsstrategien, Konfliktprävention und niederschwelliges Konfliktmanagement.
- Konfliktmanagement II: Der ressourcenorientierte Ansatz im Umgang mit Störungen.
- Das lösungsorientierte Konfliktgespräch in schulischen Kontext / Beratung und Coaching: Beratungssituationen im Kontext des Unterrichtssalltags.
- Rollenverständnis und Rollengrenzen.
- Berufsschulunterrichtsmanagement.
- Mobbing in der Schule.
- Konzepte und Praxis der betrieblichen Betreuung und Förderung.
- Jugendkriminalität und Jugendgewalt.
- Jugendkrisen und Krisenintervention.

Lecture notes
- Handouts vom Dozenten und Sammlung von Arbeitsmaterialien auf dem BSCW-Server.

Literature
Students will:
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

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<td>2S</td>
<td>M. Berkowitz Biran, T. Braas, C. M. Thurn</td>
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<td>1V</td>
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<td></td>
<td>Negotiation</td>
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<td>Self-direction and Self-management</td>
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### Educational Science for Teaching Diploma and TC - Key for Type

<table>
<thead>
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<th>Key</th>
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<tbody>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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### Key for Hours

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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 170 of 2416
### Civil Engineering (General Courses)

#### Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>101-1187-00L</td>
<td>Colloquium in Structural Engineering</td>
<td>E-</td>
<td>0 credits</td>
<td>2K</td>
<td>A. Taras, E. Chatzi, A. Frangi, W. Kaufmann, B. Stojadinovic, B. Sudret, M. Vassiliou</td>
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</table>

**Abstract**
Professors from national and international universities, technical experts from the industry as well as research associates of the institute of structural engineering (IBK) are invited to present recent research results and specific projects from the practice. This colloquium is addressed to members of universities, practicing engineers and interested persons in general.

**Objective**
Learn about recent research results in structural engineering.

<table>
<thead>
<tr>
<th>101-1387-00L</th>
<th>Colloquia in Geotechnics</th>
<th>E-</th>
<th>0 credits</th>
<th>1K</th>
<th>A. Puzrin, G. Anagnostou, I. Anastasopoulos</th>
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</thead>
</table>

**Abstract**
The Institute for Geotechnical Engineering invites distinguished speakers from research and practice, nationally and internationally. The colloquia are directed towards staff and students from Universities as well as engineers and scientists working in industry. Details can be obtained from www.igt.ethz.ch by following Events & Public Events. Some colloquia are available via webcast.

**Objective**
Learn about recent research results in geotechnics.

### Civil Engineering (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
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<td>E-</td>
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### Key for Hours

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<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 171 of 2416
Civil Engineering Bachelor

Bachelor Studies (Programme Regulations 2022)

First Year Compulsory Courses

First Year Examinations

First Year Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
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<td>3V+1U</td>
<td>M. Akka Ginosar</td>
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<tr>
<td>151-0501-03L</td>
<td>Mechanics I</td>
<td>O</td>
<td>6 credits</td>
<td>3V+2U+1K</td>
<td>R. Hopf, E. Mazza</td>
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<td>651-0032-00L</td>
<td>Geology and Petrography</td>
<td>O</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>K. Rauchenstein, M. O. Saar</td>
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<tr>
<td>101-0700-00L</td>
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<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>B. Sudret, N. Lütken</td>
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Data: 01.11.2022 12:41
Autumn Semester 2022
Lecture notes
A script will be provided. The students will discover the topics of each module through E.Tutorials that they will follow at their own pace online.

Literature
Additional book (not mandatory):

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Media and Digital Technologies</td>
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<td></td>
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<tr>
<td>Problem-solving</td>
<td></td>
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</tbody>
</table>

| Method-specific Competencies  |                        |         |
| Communication                 |                        |         |
| Creative Thinking             |                        |         |
| Integrity and Work Ethics     |                        |         |
| Self-awareness and Self-reflection |                  |         |
| Self-direction and Self-management |                |         |

| Social Competencies          |                        |         |
| Personal Competencies        |                        |         |

| Fostered competencies        |                        |         |

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies
- Analytical Competencies: assessed
- Media and Digital Technologies
- Problem-solving: assessed

Method-specific Competencies

- Social Competencies
  - Communication: not assessed
- Personal Competencies
  - Creative Thinking: not assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

851-0703-03L
Private Construction Law
Only for Civil Engineering BSc, Spatial Development and Infrastructure Systems MSc and UZH MNF Geographie/Erdsystemswissenschaften.

Objectives
As future construction practitioners, students are able to recognize legal problems independently and in good time in their daily work and to initiate the right measures.

Content
Introduction (most important sources of construction and real estate law), SIA (Swiss Society of Engineers and Architects) Design Engineering Services Contract, SIA-Norm 118 (SIA General Terms and Conditions for Construction Services), liability of designers/civil engineers, construction insurance, property law for civil engineers, sale of land, contaminated sites, statutory mortgage for contractors, public procurement, litigation in construction and real estate, the civil engineer as expert, What else to know ...

Lecture notes
There are ‘Lecture Notes’ (in German) for this course.

First Year Examination Block B

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>401-0241-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>M. Akveld, M. Felder</td>
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Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers.

Content
Complex numbers. Calculus for functions of one variable with applications. Simple Mathematical models in engineering.

Lecture notes
Wird auf der Vorlesungshomepage zu Verfügung gestellt.

Bachelor Studies (Programme Regulations 2014)

Compulsory Courses 3. Semester

Examination Block 1

<table>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0243-00L</td>
<td>Analysis III</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>M. Akka Ginosar</td>
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</table>

Abstract
We will model and solve scientific problems with partial differential equations. Differential equations which are important in applications will be classified and solved. Elliptic, parabolic and hyperbolic differential equations will be treated. The following mathematical tools will be introduced: Laplace and Fourier transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Learning to model scientific problems using partial differential equations and developing a good command of the mathematical methods that can be applied to them. Knowing the formulation of important problems in science and engineering with a view toward civil engineering (when possible). Understanding the properties of the different types of partial differential equations arising in science and in engineering.

Content
Partial differential equations
Study of the Heat equation general diffusion/parabolic problems using the following tools through Separation of variables as an introduction to Fourier Series. Systematic treatment of the complex and real Fourier Series
Study of the wave equation and general hyperbolic problems using Fourier Series, D’Alembert solution and the method of characteristics. Laplace transform and it’s uses to differential equations
Study of the Laplace equation and general elliptic problems using similar tools and generalizations of Fourier series.
Application of Laplace transform for beam theory will be discussed.

Lecture notes
Lecture notes will be provided
la part de la materia follow certain chapters of the following first two books quite closely.


The course material is taken from the following sources:

Stanley J. Farlow - Partial Differential Equations for Scientists and Engineers


Prerequisites / notice

Analysis I and II, insbesondere, gewöhnliche Differentialgleichungen.

402-0023-01L  Physics  O  7 credits  5V+2U  S. Johnson

Abstract
This course gives an overview of important concepts in classical dynamics, thermodynamics, electromagnetism, quantum physics, atomic physics, and special relativity. Emphasis is placed on demonstrating key phenomena using experiments, and in developing skills for quantitative problem solving.

Objective
The goal of this course is to make students able to explain and apply the basic principles and methodology of physics to problems of interest in modern science and engineering. An important component of this is learning how to solve new, complex problems by breaking them down into parts and applying simplifications. A secondary goal is to provide to students an overview of important subjects in both classical and modern physics.

Content
Electrodynamics, Thermodynamics, Quantum physics, Waves and Oscillations, special relativity

Lecture notes
Lecture notes and exercise sheets will be distributed via Moodle

Literature

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

101-0203-01L  Hydraulics I  O  5 credits  3V+1U  R. Stocker

Abstract
The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.

Objective
In the course “Hydraulics I”, the competency of process understanding is taught, applied and examined. Furthermore system understanding and measurement methods are taught.

Content
Properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids vs. real fluids, boundary layer, pipe flow, open channel flow, flow measurements, demonstration experiments in the lecture hall

Lecture notes
Script and collection of previous problems

Literature
Bollrich, Technische Hydromechanik 1, Verlag Bauwesen, Berlin

151-0503-00L  Dynamics  O  6 credits  4V+2U  D. Kochmann

Abstract
Dynamics of particles, rigid bodies and deformable bodies: Motion of a single particle, motion of systems of particles, 2D and 3D motion of rigid bodies, vibrations, waves

Objective
This course provides Bachelor students of mechanical and civil engineering with fundamental knowledge of the kinematics and dynamics of mechanical systems. By studying the motion of a single particle, systems of particles, of rigid bodies and of deformable bodies, we introduce essential concepts such as kinematics, kinetics, work and energy, equations of motion, and forces and torques. Further topics include the stability of equilibria and vibrations as well as an introduction to the dynamics of deformable bodies and waves in elastic rods. Throughout the course, the basic principles and application-oriented examples presented in the lectures and weekly exercise sessions help students acquire a proficient background in engineering dynamics, learn and embrace problem-solving techniques for dynamical engineering problems, gain cross-disciplinary expertise (by linking concepts from, among others, mechanics, mathematics, and physics), and prepare students for advanced courses and work on engineering applications.
Content
1. Motion of a single particle: kinematics (trajectory, velocity, acceleration), forces and torques, constraints, active and reaction forces, balance of linear and angular momentum, work-energy balance, conservative systems, equations of motion.

2. Motion of systems of particles: internal and external forces, balance of linear and angular momentum, work-energy balance, rigid systems of particles, particle collisions, apparent forces, Euler equations.

3. Motion of rigid bodies in 2D and 3D: kinematics (angular velocity, velocity and acceleration transfer, instantaneous center and axis of rotation), balance of linear and angular momentum, work-energy balance, angular momentum transport, inertial vs. moving reference frames, apparent forces, Euler equations.


5. Introduction to waves and vibrations in deformable elastic bodies: local form of linear momentum balance, waves and vibrations in slender elastic rods.

Lecture notes
Lecture notes (a scriptum) will be available on Moodle. Students are strongly encouraged to take their own notes during class.

Literature
A complete set of lecture notes (a scriptum) is available on Moodle. Further reading materials are suggested but not required for this class.

Prerequisites / notice
All course materials (including lecture notes, exercise problems, etc.) are available on Moodle.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

Examination Block 2

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<tr>
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<th>Type</th>
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<th>Lecturers</th>
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<td>101-0113-00L</td>
<td>Theory of Structures I</td>
<td>O</td>
<td>5 credits</td>
<td>3V+2U</td>
<td>B. Sudret</td>
</tr>
</tbody>
</table>

Abstract
Introduction to structural mechanics, statically determinate beams and frame structures, trusses, stresses and deformations, statically indeterminate beams and frame structures (force method)

Objective
- Understanding the response of elastic beam and frame structures
- Ability to correctly apply the equilibrium conditions
- Understanding the basics of continuum mechanics
- Computation of stresses and deformations of elastic structures
- Ability to apply the force (flexibility) method for statically indeterminate structures

Content
- Equilibrium, reactions, static determinacy
- Internal forces (normal and shear forces, moments)
- Arches and cables
- Elastic trusses
- Influence lines
- Basics of continuum mechanics
- Stresses in elastic beams
- Deformations in Euler-Bernoulli and Timoshenko beams
- Energy theorems
- Statically indeterminate systems (Force method)

Lecture notes
Bruno Sudret, "Einführung in die Baustatik" (2021)

Literature
* Bruno Sudret, "Baustatik - Eine Einführung", Springer Vieweg

Compulsory Courses 5. Semester

Examination Block 3

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<td>101-0315-00L</td>
<td>Geotechnical Engineering</td>
<td>O</td>
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<td>4G</td>
<td>A. Puzrin</td>
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</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 175 of 2416
The course explores the fundamental principles of Geomechanics and Geotechnical Engineering, with the following objectives:
- Recognition of the basic consequences of the ground construction;
- Understanding of the important fundamental concepts of Soil mechanics and Geotechnical Engineering;
- Independent analysis of the basic geotechnical problems.

After completion of the year-long course in Steel Structures I+II, students will have at their disposal a wide and detailed set of skills concerning the modern practice for steel and composite structures design and have a deep understanding of its theoretical & scientific background. The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

The content of steel structures I is a prerequisite

The lecture Steel Structures II complements the knowledge acquired in part I by providing students with additional theoretical and practical knowledge, e.g. on the design of steel and composite structures against fatigue, plate buckling, as well as on the structural modelling and analysis of more complex building and bridge structures. These more theoretical topics will be exemplified and illustrated by applications to real problems in the design of bridges and multi-storey building structures. Finally, the course will provide detailed insight into aspects pertaining to structural detailing, fabrication, erection and cost estimation for the effective design of steel and composite structures.
Content Fundamentals: Infrastructures and vehicle technologies of public transport systems; interaction between track and vehicles; passengers and goods as infrastructure users; management and financing of networks.

Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings

Vehicles: Classification, design and suitability for different goals

Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.

Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity

Lecture notes Slides, in English, are made available some days before each lecture.

Literature Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility not assessed
- Creative Thinking not assessed
- Critical Thinking not assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

101-0031-01L Systems Engineering 4 credits 4G B. T. Adey

Abstract Systems Engineering is a way of thinking that helps engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms.

This course provides an overview of the main principles of Systems Engineering, and includes an introduction to the use of operations research methods in the determination of optimal systems.

Objective The world's growing population, changing demographics, and changing climate pose formidable challenges to humanity's ability to live sustainably. Ensuring that humanity can live sustainably requires accommodating Earth's growing and changing population through the provision and operation of a sustainable and resilient built environment. This requires ensuring excellent decision-making as to how the built environment is constructed and modified.

The objective of this course is to ensure the best possible decision making when engineering sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. In this course, you will learn the main principles of Systems Engineering that can help you from the first idea that a system may not meet expectations, to the quantitative and qualitative evaluation of possible system modifications. Additionally, the course includes an introduction to the use of operations research methods in the determination of optimal solutions in complex systems.

More specifically upon completion of the course, you will have gained insight into:
- how to structure the large amount of information that is often associated with attempting to modify complex systems
- how to set goals and define constraints in the engineering of complex systems
- how to generate possible solutions to complex problems in ways that limit exceedingly narrow thinking
- how to compare multiple possible solutions over time with differences in the temporal distribution of costs and benefits and uncertainty as to what might happen in the future
- how to assess values of benefits to stakeholders that are not in monetary units
- how to assess whether it is worth obtaining more information in determining optimal solution
- how to take a step back from the numbers and qualitatively evaluate the possible solutions in light of the bigger picture
- the basics of operations research and how it can be used to determine optimal solutions to complex problems, including linear, integer and network programming, dealing with multiple objectives and conducting sensitivity analyses.
Content

The weekly lectures are structured as follows:
1. Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long terms. A high-level overview of the main principles of System Engineering. An introduction to the example that we will be working with through most of the course. The expectations of your efforts throughout the semester.
2. Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3. Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4. Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5. Analysis – 1/5 – The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, display, weighting, and expected value.
6. Analysis – 2/5 – The idea behind the supply and demand curves and revealed preference methods.
7. Analysis – 3/5 – The concept of equivalence, including the time value of money, interest, life times and terminal values.
8. Analysis – 4/5 – The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Marginal rates of return and internal rates of return.
9. Analysis – 5/5 – How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10. Evaluation of solutions – Regardless how sophisticated an analysis is, it requires that decision makers stand back and critically evaluate the results. This week we discuss the aspects of evaluating the results of an analysis.
11. Operations research – 1/4 – Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. This week we discuss linear programming and the simplex method.
13. Operations research – 3/4 – How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
14. Operations research – 4/4 – How to set up and solve problems when there are multiple objectives.

Lecture notes
- The lecture materials consist of a script, the slides and example calculations in Excel.
- The lecture materials will be distributed via Moodle two days before each lecture.

Literature
- Appropriate literature in addition to the lecture materials will be handed out when required via Moodle.

Prerequisites / notice
- This course has no prerequisites.

Fostered competencies

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<td>Negotiation</td>
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Hydrology

102-0293-00L

Abstract
The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.

Objective
Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 178 of 2416
Content

The hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

Precipitation: mechanisms of precipitation formation, precipitation measurements, variability of precipitation in space and time, precipitation regimes, point/basin precipitation, isohyetal method, Thiessen polygons, storm rainfall, design hyetograph.

Interception: measurement and estimation.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton’s equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnnian surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – basinflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rationale, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Snow (and ice) hydrology: snow characteristic variables and measurements, estimation of snowmelt processes by the energy budget equation and conceptual melt models (temperature index method and degree-day method), snowmelt runoff.

Lecture notes

The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.

Literature


Prerequisites / notice

Knowledge of statistics is a prerequisite. The required theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:

Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters).
Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

Exam Block 4

<table>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<td>101-0125-00L</td>
<td>Structural Concrete I</td>
<td>O</td>
<td>5</td>
<td>4G</td>
<td>K. Thoma</td>
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</tbody>
</table>

Abstract

The project work conceptual design conveys a first insight into the holistic approach to cope with typical tasks of civil engineering and introduces professional techniques of civil engineering to students.
A further aim is to consolidate the knowledge gained so far in bachelor courses, to link different domains and to fill gaps with respect to work techniques. The students analyse the inventory, formulate design requirements and boundary conditions, elaborate approaches and proposals for solutions, dimension some exemplary structural elements, practise detailing and document their work by different media.

Additional Compulsory Courses

<table>
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<td>Project Work Conceptual Design</td>
<td>O</td>
<td>3</td>
<td>3S</td>
<td>A. Taras, F. Ortiz Quintana</td>
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</table>

Abstract

A structure to be designed serves as a means to practice the holistic approach of conceptual design by working in parallel and iteratively on different levels of detailing. Both, requirements and scope of action, are identified by the students and serve as basis for a solution. The task group organizes itself to solve complex tasks.

Objective

The project work conceptual design conveys a first insight into the holistic approach to cope with typical tasks of civil engineering and introduces professional techniques of civil engineering to students.
A further aim is to consolidate the knowledge gained so far in bachelor courses, to link different domains and to fill gaps with respect to work techniques. The students analyse the inventory, formulate design requirements and boundary conditions, elaborate approaches and proposals for solutions, dimension some exemplary structural elements, practise detailing and document their work by different media.
Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

Materials Lab Exercises

Lecturers

ECTS

Topics:

Supervisors

ECTS

Title

The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work.

Content

Introduction into the basic and practical knowledge of important building materials and testing methods. Introduction into the basic and practical knowledge of important building materials and testing methods.

Objective

Content

Introduction of material testing equipment, with various examples of experiments on metals (tensile behaviour, hardness, bending and impact loading).

Objectives

Content

Theoretical background and practical aspects of concrete technology: mixture design, casting and setting; determination of mechanical properties.

Objective

Content

Properties of bricks and mortar: individual materials and the composite brickwork. Parameters like strength, Youngs modulus, water absorption and thermal conductivity are determined.

Supervisors

ECTS

Title

Lecture notes

Codes SIA 260, 261, 400

101-0615-01L

Materials Lab Exercises

O

4 credits

4P

R. J. Flatt, U. Angst, I. Burgert, D. Kammer, H. Richner, F. Wittel

Abstract

Introduction into the basic and practical knowledge of important building materials and testing methods.

Objective

Content

Introduction to fundamentals of Finite Element Methods and their application in examples.

Abstract

Introduction to durability of building materials and building structures: assessment of potentials for detecting and locating corrosion of steel reinforcement in concrete.

Objective

Content

For each topic a script will be provided, that can be downloaded under www.ifb.ethz.ch/education

Bachelor’s Thesis

Number

101-0606-10L

Title

Bachelor’s Thesis

Type

O

ECTS

8

Hours

17D

Lecturers

Supervisors

Recommended Courses

Number

101-0599-10L

Title

New Materiality for the Passage Notre Dame

Type

W

ECTS

2

Hours

4P

Lecturers

G. Habert

Abstract

The workshop aims at developing low carbon and long lasting materials for the renovation of the passage Notre Dame.

Objective

Content

Students will learn about embodied emissions of material production and how to overcome durability issues related with low carbon materials. It’s an hands-on workshop which lasts 10 days and is closed by a presentation in front of the main actors of the project: city of Paris, architects, industries.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Low Carbon materials explored during workshop is mainly poured earth, or earth concrete, which is a new technology well adapted to cities areas. The earth as liquid form is poured into a formwork and uncast after several hours to produce wall elements. Floors can be also done with this technology as it is currently done with concrete slab. It is a local material when excavated material from the site is used. It is nearly zero carbon as the additives used to modify its properties (water resistance, strength, fluidity) require low energy for their production (bio-additives...) and circular as the material can be returned to nature without environmental and societal impact. We will work with earth, limestone, plaster and demolished bricks and concrete as they are the main materials available in Paris.

Prerequisites / notice

A strong motivation to hands on experiments and a deep commitment to sustainability.
### Language Courses

*see Science in Perspective: Language Courses ETH/UZH*

#### Civil Engineering Bachelor - Key for Type

<table>
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#### Key for Hours

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<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<tr>
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<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<td>K</td>
<td>colloquium</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.

ECTS

This course is designed to lay down the foundation of the different concepts, techniques, and tools for successful project management of public transport design and operations.

Participants will come to understand how they can best navigate the design and building process, especially in relation to understanding the principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

The students will be randomly assigned to teams. Students will be graded as a team based on the final Project report and the in-class oral presentation of the Project Proposal as well as a final exam (50% exam and 50% project report and presentation). Homework will not be graded but your final report and presentation will consist mostly of your homework assignments consolidated and put in a report and presentation format.

Building Physics: Theory and Applications

Principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

The students will acquire in the following fields:
- Indoor and outdoor climate and driving forces.
- Hygrothermal properties of building materials.
- Building envelope solutions and their construction.
- Hygrothermal performance and durability.

Building envelope solutions and their construction.
- Hygrothermal properties of building materials.
- Indoor and outdoor climate and driving forces.

Participants will come to understand how they can best navigate the design and building process, especially in relation to understanding their profession, gaining a thorough knowledge of rules and regulations, as well as understanding how involved parties’ minds work. They will also have the opportunity to investigate ways in which they can relate to, understand, and best respond to their clients’ wants and needs. Finally, course participants will come to appreciate the various tools and instruments, which are available to them when implementing their projects. The course will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship.

"Design and Building Process MIBS" is a brief manual for prospective architects and engineers covering the competencies and the responsibilities of all involved parties through the design and building process. Lectures on twelve compact aspects gaining importance in an increasingly specialised, complex and international surrounding.

Design and Building Process MIBS

"Design and Building Process MIBS" is a brief manual for prospective architects and engineers covering the competencies and the responsibilities of all involved parties through the design and building process. Twelve compact aspects regarding the establish building culture are gaining importance in an increasingly specialised, complex and international surrounding. Lectures on the topics of profession, service model, organisation, project, design quality, coordination, costing, tendering and construction management, contracts and agreements, life cycle, real estate market, and getting started will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship. The course introduces the key figures, depicts the criteria of the project and highlights the provided services of the consultants. In addition to discussing the basics, the terminologies and the tendencies, the lecture units will refer to the studios as well as the practice: Teaching-based case studies will compliment and deepen the understanding of the twelve selected aspects. The course is presented as a moderated seminar to allow students the opportunity for individual input: active collaboration between the students and their tutor therefore required.

Design and Building Process MIBS

The students will acquire in the following fields:
- Indoor and outdoor climate and driving forces.
- Hygrothermal properties of building materials.
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**Objective**

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Objective of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view.

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

**General structure:**
- General introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning, timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.

**Content**
- Basics for line transport systems and networks
- Passenger/Supply requirements for line operations
- Objectives of system and network planning, from different perspectives and users, design dilemmas
- Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
- Planning process, from demand evaluation to line planning to timetables to operations
- Matching demand and modes
- Line planning techniques
- Timetabling principles
- Allocation of resources
- Management of operations
- Measures of realized operations
- Improvements of existing services

**Lecture notes**

Lecture slides are provided.

**Literature**

- Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

**Fostered competencies**

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**101-0509-00L Infrastructure Management 1: Process**

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Abstract

Infrastructure asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods of time. This course provides an overview of the process, from setting goals to developing intervention programs to analyzing the process itself. It consists of weekly lectures and a group project. Additionally, there is a weekly help session.
The weekly lectures are structured as follows:

**Objective**

There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines and much of the research, however, are focused on only part of the large complex problem of infrastructure asset management.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clear understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will
- understand the main tasks of an infrastructure manager and the complexity of these tasks,
- understand the importance of setting goals and constraints in the management of infrastructure,
- be able to predict the deterioration of individual assets using discrete states that are often associated with visual inspections,
- be able to develop and evaluate simple management strategies for individual infrastructure assets,
- be able to develop and evaluate intervention programs that are aligned with their strategies,
- understand the principles of guiding projects and evaluating the success of projects,
- be able to formally model infrastructure management processes, and
- understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.

**Content**

The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.
2. Positioning infrastructure management in society: As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.
3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.
4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.
5. Help session 1
6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.
7. Determining and justifying monitoring - Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.
8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.
9. Help session 2
10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.
11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.
12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.
13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.
14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

**Lecture notes**

- The lecture materials consist of handouts, the slides, and example calculations in Excel.
- The lecture materials will be distributed via Moodle two days before each lecture.

**Literature**

Appropriate literature will be handed out when required via Moodle.

**Prerequisites / notice**

This course has no prerequisites.
An Introduction to Sustainable Development in the Built Environment

Abstract
In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict. What does it mean for the built environment?

This course provides an introduction to the notion of sustainable development when applied to our built environment.

Objective
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content
The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world

- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

### Major in Geotechnical Engineering

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<th>Number</th>
<th>Title</th>
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<td>W+</td>
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<td>2G</td>
<td>G. Anagnostou, A. Nordas, E. Pimentel</td>
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</table>

Abstract
Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.

Objective
Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.
Content
Numerical analysis methods in tunnelling.
Conventional excavation methods (full face, top heading and bench, side drift method, ...)
Auxiliary measures:
- Injections
- Jet grouting
- Ground freezing
- Drainage
- Forepoling
- Face reinforcement

Numerical analysis methods in tunnelling.
Conventional excavation methods (full face, top heading and bench, side drift method, ...)
Auxiliary measures:
- Injections
- Jet grouting
- Ground freezing
- Drainage
- Forepoling
- Face reinforcement

Lecture notes
Autographieblätter

Literature
Empfehlungen

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed

Analytical Competencies
Decision-making
assessed

Method-specific Competencies

101-0357-00L  Theoretical and Experimental Soil Mechanics
Prerequisites: Mechanics I, II and III.

The number of participants is limited to 60 due to the existing laboratory equipment! Students with major in Geotechnical Engineering have priority. Registrations will be accepted in the order they are received.

Abstract
Overview of soil behaviour
Explanation of typical applications: reality, modelling, lab tests with transfer of results to practical examples
Consolidation theory and typical applications
Triaxial tests: consolidation & shear, drained & undrained response
Plasticity theory & Critical State Soil Mechanics, Cam Clay
Application of plasticity theory
Introduction to physical modelling

Objective
(1) Extend knowledge of theoretical approaches that can be used to describe soil behaviour.
(2) Offer the opportunity to perform hands-on element tests required for constitutive model calibration.
(3) Enable students to select an appropriate constitutive model and calibrate it using element test performed in the lab.
(4) Enable students to carry out FE analyses for realistic geotechnical applications.

Content
Overview of soil behaviour
Discussion of general gaps between basic theory and soil response
Stress paths in practice & in laboratory tests
Explanation of typical applications: reality, modelling, laboratory tests with transfer of results to the practical examples
Consolidation theory for incremental and continuous loading oedometer tests and typical applications in practice
Triaxial & direct shear tests: consolidation & shear, drained & undrained response
Plasticity theory & Critical State Soil Mechanics, Cam Clay
Application of plasticity theory
Introduction to physical modelling with emphasis on centrifuge modelling

Lecture notes
Printed script with web support
Exercises

Literature
https://moodle-app2.let.ethz.ch/

Prerequisites / notice
Pre-requisites: Fundamental knowledge of solid and soil mechanics.

The theoretical part of the course will be covered by problem-based lectures. The experimental part will be covered by hands-on element tests performed by the students in the laboratory. These experimental results will be instrumental in the calibration of advanced soil constitutive models. The connection between the experimental and theoretical parts of the course will be facilitated by means of numerical investigations (i.e., FE analyses), including the selection and calibration of relevant constitutive models. The numerical investigations shall be documented by the students in a final report.

Laboratory equipment will be available for 60 students. Students registered for the Geotechnics Specialty in Masters will be given priority as follows: (1) 2nd year students; (2) 1st year students, (3) doctoral students taking the class for their qualifying exam; Further students will be admitted on a first-come-first-served basis.

101-0307-00L  Design and Construction in Geotechnical Engineering

Abstract
This lecture deals with the practical application of the knowledge gained in the fundamental lectures from the Bachelor degree. The basics of planning and design of geotechnical structures will be taught for the main topics geotechnical engineers are faced to in practice.

Objective
Transfer of the fundamental knowledge taught in the Bachelor degree to practical application.
Ability to plan and design geotechnical structures based on the state of the art.

Content
Introduction to Swisscode SIA
Foundations and settlements
Pile foundations
Excavations
Slopes
Soil nailing
Reinforced geosystems
Ground improvement
River levees

Lecture notes
Script in the form of chapters and powerpoint overheads with web support (moodle-app2.let.ethz.ch)
Exercises

Literature
Relevant literature will be stated during the lectures

Prerequisites / notice
Pre-condition: Successful examinations (pass) in the geotechnical studies (soil mechanics and ground engineering, each 5 credits) in the Bachelor degree of Civil Engineering (ETH), or equivalent for new students.

The lecture contains at least one presentation from practice.

101-0369-00L  Forensic Geotechnical Engineering

Prerequisites: successful participation in "Geotechnical Engineering" (101-0315-00L) or an equivalent course.

Abstract
This lecture deals with the practical application of the knowledge gained in the fundamental lectures from the Bachelor degree. The basics of planning and design of geotechnical structures will be taught for the main topics geotechnical engineers are faced to in practice. The connection between the experimental and theoretical parts of the course will be facilitated by means of numerical investigations (i.e., FE analyses), including the selection and calibration of relevant constitutive models. The numerical investigations shall be documented by the students in a final report.

Laboratory equipment will be available for 60 students. Students registered for the Geotechnics Specialty in Masters will be given priority as follows: (1) 2nd year students; (2) 1st year students, (3) doctoral students taking the class for their qualifying exam; Further students will be admitted on a first-come-first-served basis.

Objective
Transfer of the fundamental knowledge taught in the Bachelor degree to practical application.
Ability to plan and design geotechnical structures based on the state of the art.

Content
Introduction to Swisscode SIA
Foundations and settlements
Pile foundations
Excavations
Slopes
Soil nailing
Reinforced geosystems
Ground improvement
River levees

Lecture notes
Script in the form of chapters and powerpoint overheads with web support (moodle-app2.let.ethz.ch)
Exercises

Literature
Relevant literature will be stated during the lectures

Prerequisites / notice
Pre-condition: Successful examinations (pass) in the geotechnical studies (soil mechanics and ground engineering, each 5 credits) in the Bachelor degree of Civil Engineering (ETH), or equivalent for new students.

The lecture contains at least one presentation from practice.

101-0369-00L  Forensic Geotechnical Engineering

Prerequisites: successful participation in "Geotechnical Engineering" (101-0315-00L) or an equivalent course.

Abstract
This lecture deals with the practical application of the knowledge gained in the fundamental lectures from the Bachelor degree. The basics of planning and design of geotechnical structures will be taught for the main topics geotechnical engineers are faced to in practice. The connection between the experimental and theoretical parts of the course will be facilitated by means of numerical investigations (i.e., FE analyses), including the selection and calibration of relevant constitutive models. The numerical investigations shall be documented by the students in a final report.

Laboratory equipment will be available for 60 students. Students registered for the Geotechnics Specialty in Masters will be given priority as follows: (1) 2nd year students; (2) 1st year students, (3) doctoral students taking the class for their qualifying exam; Further students will be admitted on a first-come-first-served basis.

Objective
Transfer of the fundamental knowledge taught in the Bachelor degree to practical application.
Ability to plan and design geotechnical structures based on the state of the art.

Content
Introduction to Swisscode SIA
Foundations and settlements
Pile foundations
Excavations
Slopes
Soil nailing
Reinforced geosystems
Ground improvement
River levees

Lecture notes
Script in the form of chapters and powerpoint overheads with web support (moodle-app2.let.ethz.ch)
Exercises

Literature
Relevant literature will be stated during the lectures

Prerequisites / notice
Pre-condition: Successful examinations (pass) in the geotechnical studies (soil mechanics and ground engineering, each 5 credits) in the Bachelor degree of Civil Engineering (ETH), or equivalent for new students.

The lecture contains at least one presentation from practice.
In this course selected famous geotechnical failures are investigated with the following purpose: (a) to deepen understanding of the geotechnical risks and possible solutions; (b) to practice design and analysis methods; (c) to learn the techniques for investigation of failures; (d) to learn the techniques for mitigation of the failure damage.

After passing this course students will be able to:
1. Explain the equilibrium of continuous structural elements.
2. Formulate mechanical models of continuous prismatic structural elements.
3. Analyze the axial, shear, bending and torsion load-deformation response of prismatic structural elements and structures assembled using these elements.
4. Determine the state of forces and deformations in rods, beams, frame structures, arches, cables and rings under combined mechanical and thermal loading.
5. Use the theory of continuous structures to design structures and understand the basis for structural design code provisions.

This is the third course in the ETH series on theory of structures. Building on the material covered in previous courses, this course focuses on the axial, shear, bending and torsion load-deformation response of continuous elastic prismatic structural elements such as rods, beams, shear walls, frames, arches, cables and rings. Additional special topics, such as the behavior of inelastic prismatic structural elements or the behavior of planar structural elements and structures, may be addressed time-permitting.

This course focuses on the axial, shear, bending and torsion load-deformation response of continuous elastic prismatic structural elements such as rods, beams, shear walls, frames, arches, cables and rings. Additional special topics, such as the behavior of inelastic prismatic structural elements or the behavior of planar structural elements and structures, may be addressed if time permits. The course provides the theoretical background and engineering guidelines for practical structural analysis of modern structures.

Electronic copies of the learning material will be managed using Moodle. The learning material includes the lecture presentations, additional reading, and exercise problems and solutions. Lectures are streamed live and recorded on the ETH Video Portal.


Working knowledge of theory of structures, as covered in ETH course Theory of Structures I (Baustatik I) and Theory of Structures II (Baustatik II) and ordinary differential equations. Basic knowledge of structural design of reinforced concrete, steel or wood structures. Familiarity with structural analysis computer software and computer tools such as Matlab, Mathematica, Mathcad or Excel.
Steel Structures III: Advanced Steel and Composite Structures

101-0137-00L

Abstract
Expand the theoretical background and practical knowledge in the design and construction of steel and composite structures. The course of the focus lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. Students will learn how to solve complex structural engineering tasks in larger building projects, e.g. through the use and correct design of large-span slim-floor girders and ultra-slim composite columns, or the use of glazing and cable structures as principal load-carrying components. They learn how steel structures behave under fire conditions and how they can be protected and designed accordingly. Finally, students learn about the fundamental aspects governing the design of specialty steel structures, such as thin-walled cold-formed sections, crane girders, masts and storage tanks.

The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

Fostered competencies

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<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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<td>Analytical Competencies</td>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td></td>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>


### Content

Steel Structures III provides in-depth theoretical background and practical knowledge on advanced design topics in steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. The course discusses the use and design of large-span slim-floor girders and ultra-slimter composite columns, as well as the use of glazing and cable structures as principal load-carrying components. The design of steel structures under elevated temperatures (fire conditions) is treated, as well as special topics of design for serviceability. In addition, fundamental concepts of the design of cold-formed steel framed structures are discussed. Finally, the course will give an overview of the design of specialty steel structures, such as crane girders, masts and storage tanks.

### Lecture notes

Slides and lecture notes. Worked examples. Handouts and formula collections.

### Literature

Stahlbaukalender (various editions), Ernst + Sohn, Berlin

### Prerequisites / notice

Prerequisites: Steel Structures I and II

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<td>Structural Reliability and Risk Analysis</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Marello</td>
</tr>
<tr>
<td>101-0157-01L</td>
<td>Structural Dynamics and Vibration Problems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Vassiliou, V. Nierthmanis</td>
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<tr>
<td>151-8015-00L</td>
<td>Moisture Transport in Porous Media</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>J. Carmeliet, L. Fei, D. A. Strebel</td>
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### Objective

The course provides an introduction to structural reliability, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

### Content

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

### Lecture notes

Slides and lecture notes. Worked examples. Handouts and formula collections.

### Literature


S. Marello, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

### Prerequisites / notice

Basic course on probability theory and statistics.
Conceptual design, detailing and structural analysis of multi-storey timber buildings as well as timber roof structures and halls.

Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, 2G

Field of application of timber structures; Timber as building material (wood structure, physical and mechanical properties of wood and wood-based products); Durability; Principles of design and dimensioning; Connections (dowels, nails, screws, glued connections); Timber components and assemblies (mechanically jointed beams, trusses); Design and detailing of multi-storey timber buildings as well as timber roof structures and halls.

At the end of the course, you shall be able to

1) Design advanced FRP composites for your structures,

2) To consult owners and clients with necessray testing and SHM techniques for FRP structures,

3) Continue your education as a phd student in this field.

Content

Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes

Power Point Presentations available online at www.empa.ch/abt303

Prerequisites / notice


3) Continue your education as a phd student in this field.

Literature

1) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019


3) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components

4) Working with Composite Materials in the Laboratory (application, testing, etc)

101-0637-01L Timber Structures I

Abstract

Comprehensive and application of basic knowledge of structural timber design including material behaviour especially anisotropy, moisture and long duration effects and their consideration in structural analysis and detailing. Conceptual design, detailing and structural analysis of multi-storey timber buildings as well as timber roof structures and halls.

Objective

Field of application of timber structures; Timber as building material (wood structure, physical and mechanical properties of wood and wood-based products); Durability; Principles of design and dimensioning; Connections (dowels, nails, screws, glued connections); Timber components and assemblies (mechanically jointed beams, trusses); Design and detailing of multi-storey timber buildings as well as timber roof structures and halls.
Abstract
This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

Objective
At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=11917). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

Content
Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:
1. Local potentials
2. Demand
3. Supply

Lecture notes
The slides of the lecture serve as lecture notes and are available as download.

Literature
A list of relevant literature is available at the chair.

Prerequisites / notice
This course can only be taken if Energy and Climate Design II is taken in the following semester, as the group work is connected and extends throughout the year.

101-0617-02L Computational Science Investigation for Material Mechanics

Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

Objective
Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can often only be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content
1 Introduction to (numeric) forensic engineering
2 The nature of engineering problems (governing equations)
3 Numerical recipes for dealing with non-linear problems
4 Multi-field problems (HTM)
5 On the nature of failure - Physics of damage and fracture
6 Cracks and growth in structures (LEFM and beyond)
7 Introduction to metal plasticity
8 Damage and fracture in heterogeneous materials
9 Mechanics of fatigue
10 Visco-elastic failure
11 Student -Project presentation

Lecture notes
Will be provided during the lecture via moodle.

Literature
Will be provided during the lecture.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Method-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Social Competencies
- Communication
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Personal Competencies
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
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Method-specific Competencies
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 191 of 2416
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**Abstract**

This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system. Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view. At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

**General structure:**
- General introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning, timetabling and tactical planning, and related mathematical approaches
- Operations, and quantitative support to operational problems, evaluation of public transport systems.

**Content**
- Basics for line transport systems and networks
- Passenger/Supply requirements for line operations
- Objectives of system and network planning, from different perspectives and users, design dilemmas
- Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
- Planning process, from demand evaluation to line planning to timetables to operations
- Matching demand and modes
- Line planning techniques
- Timetabling principles
- Allocation of resources
- Management of operations
- Measures of realized operations
- Improvements of existing services

**Lecture notes**

- Lecture slides are provided.

**Literature**
- Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466653919 (English)

**Fostered competencies**

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**101-0437-00L Traffic Engineering**

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<tr>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>S. Mousavi, M. Makridis</td>
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**Abstract**

Fundamentals of traffic flow theory and control.

**Objective**

The objective of this course is to fully understand the fundamentals of traffic flow theory in order to effectively manage traffic operations. By the end of this course students should be able to apply basic techniques to model different aspects of urban and inter-urban traffic performance, including congestion.

**Content**

Introduction to fundamentals of traffic flow theory and control. Includes understanding of traffic data collection and processing techniques, as well as data analysis, traffic modeling, and methodologies for traffic control.
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve problems in engineering.

**Introduction to Mathematical Optimization**

The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

**Prerequisites / notice**

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advanced lecture course discussing central tasks and possible solutions for current and future challenges of spatial development in Switzerland and Europe. To cope with the problem, the course is divided into sub-problems, which are solved using various statistical models (e.g., regression, discrete choice analysis) and algorithms (e.g., iterative proportional fitting, shortest path algorithms, method of successive averages). The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis. Interim lab sessions take place regularly to guide and support students with the applied part of the course.

**Lecture notes**

Moodle platform (enrollment needed)

**Literature**


### Basics of Air Transport (Aviation I)

**W 4 credits 3G P. Wild**

**Abstract**
In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation. The program is taught in English and we provide 11 different experts/lecturers.

**Objective**
The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport. Ideal foundation for Aviation II - Management of Air Transport.

**Content**
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

- Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

- Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

- Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

**Lecture notes**
Preparation materials & slides are provided prior to each class

**Literature**
Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

**Prerequisites / notice**
The lecture is planned as class teaching.

### Railway Systems I

**227-0523-00L**

**Abstract**
Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

**Objective**
- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators
EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrdynamik

2 Vollbahnfahrzeuge:
2.1 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebssysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung

3 Infrastruktur:
3.1 Fahrweg
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen

4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
Betriebszentrale SBB, Zürich Flughafen
Reparatur und Unterhalt, SBB Zürich Altstetten
Fahrzeugfertigung, Stadler Bussnang

Lecture notes
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice
Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

Fostered competencies

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<tr>
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<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
<th>Critical Thinking</th>
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<td>Personal Competencies</td>
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**101-0509-00L Infrastructure Management 1: Process**

**W 6 credits 2G B. T. Adey**

**Abstract**

Infrastructure asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods of time. This course provides an overview of the process, from setting goals to developing intervention programs to analyzing the process itself. It consists of weekly lectures and a group project. Additionally, there is a weekly help session.

There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines and much of the research, however, are focused on only part of the large complex problem of infrastructure asset management.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clear understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will

- understand the main tasks of an infrastructure manager and the complexity of these tasks,
- understand the importance of setting goals and constraints in the management of infrastructure,
- be able to predict the deterioration of individual assets using discrete states that are often associated with visual inspections,
- be able to develop and evaluate simple management strategies for individual infrastructure assets,
- be able to develop and evaluate intervention programs that are aligned with their strategies,
- understand the principles of guiding projects and evaluating the success of projects,
- be able to formally model infrastructure management processes, and
- understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.
The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.

2. Positioning infrastructure management in society. As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.

3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.

4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.

5. Help session 1

6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.

7. Determining and justifying monitoring – Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.

8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.

9. Help session 2

10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.

11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.

12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.

13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.

14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

The lecture materials will be distributed via Moodle two days before each lecture.

Appropriate literature will be handed out when required via Moodle.

This course has no prerequisites.

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptable and Flexible: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Urban Systems and Transportation

This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.
The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic forces that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

### Major in Hydraulic Engineering and Water Resources Management

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<td>O</td>
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<td>K. Sperger, I. Albayrak, F. Evers, B. Hohermuth</td>
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</table>

**Abstract**

Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design with regard to economy and safety are provided.

**Objective**

Knowledge of hydraulic structures and their functions within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.

**Content**

- Weirs: Weir stability, gates, inflatable dams, appurtenant structures, fish up- and downstream passages.
- Conduits: Design of head races, pressure shafts, and penstocks, constructive details and construction.
- Power plants: Power house and turbine types, design, structure, construction.
- Dams: Types, appurtenant structures (temporary diversions, spillways, bottom and low-level outlets), dam type selection criteria, layout and design of gravity dams, buttress dams, arch dams, rockfill dams with central core or concrete face, measures in the foundation, mass concrete, RCC dams, reservoir siltation and sediment management, dam surveillance.
- Artificial reservoirs: Purpose, layout, sealing, appurtenant structures, environmental aspects.

**Lecture notes**

Course slides will be made available to students prior to each class.

**Literature**

Course slides will be made available to students.
River Engineering

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on

Abstract
The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

Objective
At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content
The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Lecture notes
Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

Literature
1. «Flussbau» lecture notes of fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance)
2. Erosion and Sedimentation; Pierre Y. Julien
3. River Mechanics; Pierre Y. Julien

Prerequisites / notice
Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Fostered competencies

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<td>Self-direction and Self-management</td>
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Watershed Modelling

Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

Content
The first part (A) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and parameter calibration and model validation, and analysis of uncertainty. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
Literature consists of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 198 of 2416
101-0250-00L  Solving Partial Differential Equations in Parallel on GPUs

Abstract
This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

Objective
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Content
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn about the diffusion process and how to solve it;
- Understand the practical challenges of parallel and distributed computing: (multi-)GPUs, multi-core CPUs;
- Learn about software development tools: git, version control, continuous integration (CI), unit tests.

Part 2 - Developing your own parallel algorithms
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Implement efficient iterative algorithms;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPUs);
- Learn about main simulation performance limiters.

Part 3 - Final project
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

101-0677-00L  Concrete Technology

Abstract
Opportunities and limitations of concrete technology. Commodities and leading edge specialties.

Objective
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.

Content
Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as self compacting concrete
- fibre reinforced concrete
- fast setting concrete
- fair faced concrete
- recycled concrete
- new research in digital fabrication with concrete

Lecture notes
Slides provided for download.

Fostered competencies

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 199 of 2416
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<td>151-0353-00L</td>
<td>Mechanics of Composite Materials</td>
<td>W</td>
<td>4</td>
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<td>101-0617-01L</td>
<td>Advances in Building Materials</td>
<td>W</td>
<td>4</td>
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<td>R. J. Flatt, I. Burgert</td>
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**Abstract**
- **Moisture Transport in Porous Media**
  - Moisture transport and related degradation processes in porous materials
  - Theory of moisture transport in porous materials
  - Experimental determination of moisture transport properties
  - Liquid transport in cracked porous media, Drying of porous media, microclimate in urban street canyons.

**Objective**
- Basic knowledge of moisture transport and related degradation processes in porous materials
- Knowledge of experimental determination of moisture transport properties
- Application of knowledge to moisture transport in cracked materials, drying of porous materials and microclimate in urban street canyons

**Content**
1. **Introduction**
   - Moisture damage: problem statement, durability
   - Applications: building materials, soil science, geoscience

2. **Moisture transport: theory and application**
   - Description of moisture transport
   - Determination of moisture transport properties
   - Exercises on moisture transport properties

3. **Special topics**
   - Liquid transport in cracked materials, Drying of porous materials, Microclimate in urban street canyons

**Fostered competencies**
- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

**Lecture notes**
- Handouts, supporting material and exercises are provided online via Moodle.

**Literature**
- All material is provided online via Moodle.

**151-0353-00L Mechanics of Composite Materials**
- Focus is on laminated fibre reinforced polymer composites.
- The course treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

**Objective**
- To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

**Content**
- The course is addressing following topics:
  - Introduction
  - Elastic anisotropy
  - Micromechanics aspects
  - Classical Laminate Theory (CLT)
  - Failure hypotheses and damage analysis
  - Analysis and design of composite structures
  - Thin ply composite shells & effects of material non-linearity

**Lecture notes**
- Script, handouts, exercises and additional material are available in PDF-format on moodle page of the lecture.

**Literature**
- The lecture material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced in there.

**Fostered competencies**
- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

**101-0617-01L Advances in Building Materials**
- The course material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced in there.

**Fostered competencies**
- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies
Abstract
The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

Objective
In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

Content
This course for civil engineers lays the grounds in the specialization Materials and Mechanics and complements the second introductory course of the specialization on Numerical Mechanics of Materials. The course also addresses master students in Materials Science and other study programs interested in deepening their understanding of application-relevant properties of engineering materials and sustainability related challenges.

The following topics are covered:
1. Material selection
2. Materials and sustainability 1
3. Materials and sustainability 2
4. Recyclability
5. Material science of wood durability
6. Material science of concrete durability
7. Foams in construction and thermal insulation
8. Sealants and adhesives in construction
9. Coatings
10. Flame retardants
11. Future of wood – 1
12. Future of wood – 2
13. Future of concrete – 1
14. Future of concrete – 2

Lecture notes
Handouts will be provided for each lecture.

101-0617-02L Computational Science Investigation for material Mechanics
Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

Objective
Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can only often be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content
1 Introduction to (numeric) forensic engineering
2 The nature of engineering problems (governing equations)
3 Numerical recipes for dealing with non-linear problems
4 Multi-field problems (HTM)
5 On the nature of failure - Physics of damage and fracture
6 Cracks and growth in structures (LEFM and beyond)
7 Introduction to metal plasticity
8 Damage and fracture in heterogeneous materials
9 Mechanics of fatigue
10 Visco-elastic failure
11 Student -Project presentation

Lecture notes
Will be provided during the lecture via moodle.

Literature
Will be provided during the lecture.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
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<tr>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<tr>
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<tr>
<td>Problem-solving</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td>Personal Competencies</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-direction and Self-management</td>
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3. Semester

Major Courses

Major in Construction and Maintenance Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>101-0549-00L</td>
<td>Selected Topics on Legal Aspects in Civil Engineering</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>H. Briner, D. Trümpey</td>
</tr>
</tbody>
</table>

Abstract
Basic knowledge in public and private law of civil engineering. Examples of the subjects treated: space management, protection of the environment, legal procedures, standards for building technology and contracts.

Objective
Part 1: The students shall acquire basic knowledge of the public law concerning civil engineering: space management, conception of buildings, protection of the environment, procedures
Part 2: The students shall acquire basic knowledge of the private law concerning civil engineering
Content

Teil 1: Jede Lektion behandelt für ein bestimmtes Stadium des Projekts ein Thema des öffentlichen Baurechts wie Bau- und Zonenordnungen, Quartierpläne, Umweltverträglichkeitsprüfungen, Baubewilligungsverfahren etc.

Teil 2: Grundzüge des privaten Baurechts wie Abnahme und Genehmigung von Bauwerken, Vollmacht des Architekten / Ingenieurs zu Rechtsanwaltungen namens des Bauherrn, Mängelrüge im Bauwesen, Mehrheit ersatzpflichtiger Baubeteiligter, Generalunternehmervertrag, Haftung des Baumaterialverkäufers, Bauhandwerkerpfandrecht, Grundzüge der SIA-Norm 118, Baukonsortium, technische Normen, internationale Bauverträge, Architekten / Ingenieure als Gerichtsexperten, Aspekte des Bauzivilprozesses

Lecture notes

D. Trümpy; Folien zu den Grundzügen des schweizerischen Bauvertragsrechts, Haftungs- und Prozessrechts (Vorlesungsunterlage)

H. Briner: Tafeln zu den Grundzügen des öffentlichen Raumplanungs-, Bau- und Umweltrechts (Vorlesungsunterlage)

Literature

- Stöckli P./Siegenthaler Th. (Hrsg.) Die Planerverträge, Schulthess 2013
- Gauch Peter, Werkvertrag, 5. Auflage, Schulthess 2011

Prerequisites / notice

Die Teilnehmer sollen stets ein Exemplar der SIA-Norm 118, der SIA-LHO 103 sowie die Gesetzesausgaben von OR und ZGB bei sich haben.

Workshop on Sustainable Building Certification 101-0587-00L

W+ 3 credits 2G

Abstract

Building labels are used to certify buildings and neighbourhoods in terms of sustainability. Many different labels have been developed and can be used in Switzerland (LEED, DGNB, SNBS, Minergie, 2000-Watt-Sites). In this course the differences between the certification labels and its application on 3 emblematic case study buildings will be discussed.

Objective

After this course, the students are able to understand and use the different certification labels. They have a clear view of what the labels take into consideration and what they don't.

Content

Three buildings case study will be presented.

Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

After this overall general presentation and in order to have a closer look to specific aspects of sustainability, students will work in groups and assess during one or two weeks this specific criteria on one of the case studies presented before. This practical hands on the label will end with a presentation and a discussion where we will highlight differences between the labels.

This alternation of working session on one specific criteria for one specific building followed by a group presentation and discussion to compare labels is repeated for the different focus point (operation energy, mobility, daylight, indoor air quality).

Lecture notes

The slides from the presentations will be made available.

Literature

All documents for certification labels as well as detail plans of the buildings will be available for the students.

Project Management: Project Execution to Closeout 101-0520-00L

W+ 4 credits 2G J. J. Hoffman

Abstract

The course will give Engineering students a comprehensive overview and enduring understanding of the techniques, processes, tool and terminology to manage the Project Triangle (time, cost, Quality) and to organize, analyze, control and report a complex project from start of Project Execution to Project Completion. Responsibilities will be detailed in each phase of the execution.

Objective

A student after completing the course will have the understanding of the Project Management duties, responsibilities, actions and decisions to be done during the Execution phase of a complex project.

Content

Execution Phase of the Project

Engineering Management - Scope, EV Measurement, Reporting and Organization
Procurement and Transportation - Scope, EV Measurement, Reporting and Organization
Civil Construction and Erection - Scope, EV Measurement, Reporting and Organization
Financial Reporting and forecasting
Risk & Opportunity Identification Assessment and Quantification during Execution
Team Organization and Leadership
Risk and opportunity identification and quantification
Contract Claims and Delays
Execution Quality
Environmental Health and safety during execution

Literature

Required and suggested reading will be uploaded on weakly basis.

Prerequisites / notice

Prerequisite for this course is course Project Management: Pre-Tender to Contract Execution number 101-0517-01 G, unless otherwise approved by the lecturer.

Design-Integrated Life Cycle Assessment 101-0608-00L

W 3 credits 2G G. Habert, A. Galimshina

Abstract

Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process.

The aim of this course is to apply LCA during the design of buildings by means of a digital, parametric tool. The necessary fundamentals of the LCA method will be taught following a lecture on demands approach.

Objective

The course will follow two main objectives and a third optional objective, depending on the design projects the students’ choose. At the end of the course, the students will:

1. Know the methodology of LCA
2. Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation
In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change.

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

An Introduction to Sustainable Development in the Built Environment

**Objective**

At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

**Content**

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

**Methods**

- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

**Main issues:**

- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world

- Synthesis: Transition to sustainable development

**Lecture notes**

All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

**Literature**

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

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**101-0577-00L Ad Introduction to Sustainable Development in the Built Environment**

**Abstract**

In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict. What does it mean for the built environment?

This course provides an introduction to the notion of sustainable development when applied to our built environment.

**Objective**

At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focusing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

**Content**

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

**Methods**

- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

**Main issues:**

- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world

- Synthesis: Transition to sustainable development

---

**101-0527-10L Materials and Constructions**

**Abstract**

Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction

**Prerequisites / notice**

Prerequisite: Sustainable construction (101-0577-00L). Otherwise a special permission by the lecturer is required.

The lecture series will be conducted in English and is aimed at students of master's programs, particularly the departments ARCH, BAUG, ITET, MAVT, MTEC and UWIS.

No lecture will be given during Seminar week.
Objective
Special focus on regenerative materials: earth, bio-based and reuse
The students will acquire knowledge in the following fields:
- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope:
  - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
  - Insulating materials (bio-based vs conventional)
  - Air barrier, vapour barrier and sealants
- Interior finishing
- Assessment of materials and components behaviour and performance
- Solutions for energy retrofitting of (historical) buildings
- Aspects of sustainability and durability

Content
Introduction
Sustainable cement and concrete
Earth construction
Visit
Steel and bamboo
Timber construction
Building physic and conventional insulation
Bio-based insulation
Finishing
Reuse

-major in Geotechnical Engineering

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<thead>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>101-0329-00L</td>
<td>Tunnelling III</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>G. Anagnostou, E. Pimentel, M. Ramoni</td>
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</tbody>
</table>

Abstract
Deepen the knowledge on selected topics of underground construction as well as learning working out conceptual solutions of complex problems.

Objective
Lecture: Deepen the knowledge on selected topics of underground construction.
Exercises: Conceptual solutions of complex problems.

Content
Caverns: Geometry, construction methods, support.
Shafts: Construction methods, support.
Urban tunnelling: Boundary conditions, system choice, alignment, design.
Field measurements: Principles, monitoring layout, applications, interpretation.
Cut and cover tunnels: Modelling, design.
Exercising conceptual solution of complex tunnelling problems based upon discussion of current tunnel cases with particularly demanding problems in small groups.

Lecture notes
Autographieblätter

Literature
Empfehlungen
Prerequisite: BSc course “Tunnelling”, MSc courses “Tunnelling I” and “Tunnelling II”.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

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<tr>
<td>101-0339-00L</td>
<td>Environmental Geotechnics</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Plötze</td>
</tr>
</tbody>
</table>

Abstract
Introduction of basic knowledge about problems with contaminated sites, investigation of this sites, risk management, remediation and reclamation techniques as well as monitoring systems.

Objective
Introduction in landfill design and engineering with focus on barrier- and drainage systems and lining materials, evaluation of geotechnical problems, e.g. stability.

Content
Definition of contaminated sites, site investigation methods, historical research and technical investigation, risk assessment, contamination transport, remediation, clean-up and retaining techniques (e.g. bioremediation, incineration, retaining walls, pump-and-treat, permeable reactive barriers), monitoring, research projects and results

Prerequisites / notice
excursion

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Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Abstract
Road design criteria, Technology of road construction materials, geotechnical testing methods in Laboratory and in situ, Planning, monitoring and interpretation of soil field tests, Soil classification for traffic construction, Compaction of road structures and dams, Frost characteristics of soil materials, soil stabilization

Objective
Aim of the course is to teach students the most important aspects of the road structure, its building and design methods. An essential part of the course is devoted to understand the influence of the in-situ conditions: soil, underground, climate, water, as well as of the characteristics of building materials and of road surface on the durability of the pavement.

Content
Road design criteria, Technology of road construction materials, geotechnical testing methods in Laboratory and in situ, Planning, monitoring and interpretation of soil field tests, Soil classification for traffic construction, Compaction of road structures and dams, Frost characteristics of soil materials, soil stabilization
The course overviews advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to excessive loading effects and energy dissipation mechanisms. Their understanding is necessary for reliably computing structural capacity. In this course, instead of blindly using generic structural analysis software, we offer an explicit understanding of what goes on behind the curtains, by explaining the algorithms that are used in such software.

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems

The course slides serve as Script. These are openly available on: http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

Useful (optional) Reading:

Prerequisites:
- 101-0158-01 Method of Finite Elements I (FS)
- A good knowledge of Python is necessary for attending this course.
After successfully completing this course, the students will be able to:

1. Model and explain the seismic behavior of new structures with moment frame, braced frame and shear wall structural systems.
2. Evaluate the performance of new structures under earthquake loading using modern risk-informed performance assessment methods and analysis tools.
3. Use the knowledge of nonlinear dynamic response of structures to interpret the design code provisions and apply it in seismic design of structural systems.
4. Successfully design such systems to achieve the performance objectives stipulated by the design codes.

This course completes the series of courses on dynamic analysis and seismic design of structures at ETHZ. Building on the material covered in Structural Dynamics and Seismic Design of Structures I, the following advanced topics will be covered in this course: 1) behavior and non-linear response modeling of structural systems under earthquake excitation; 2) displacement-based inelastic design of new building structures; 3) seismic design of moment frame, braced frame and shear wall structures; These topics will be discussed from the standpoint of risk-informed performance-based seismic design.

Moodle is used to manage the course learning material. These include the lecture presentations, additional reading, exercise problems and solutions, example models of structures in OpenSees system for earthquake engineering simulation, and example designs. Lectures are streamed and recorded using the ETH Video Portal.

Number of participants limited to 18. All students go on a waiting list. Final registration based on an application letter (information given in the first lecture). Priority will be given to students who completed Seismic Design of Structures I (101-0188-00 G) and are in the primary target group (majoring in Structural Engineering and/or doing project-based coursework for other majors).

<table>
<thead>
<tr>
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<td></td>
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<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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<td></td>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
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</table>

**Abstract**

This course will cover the analysis and design of isolation systems to mitigate earthquakes and other forms of vibrations. The course will cover:

1. Conceptual basis of seismic isolation, seismic isolation types, mechanical characteristics of isolators.
3. Design approaches and code requirements.

**Objective**

After successfully completing this course the students will be able to:

1. Understand the mechanics of and design isolator bearings.
2. Understand the dynamics of and design an isolated structure.

**Content**

1. Introduction: Overview of seismic isolation; review of structural dynamics and earthquake engineering principles. Viscoelastic behavior.
2. Linear theory of seismic isolation
4. Behavior of rubber isolators under shear and compression
5. Behavior of rubber isolators under bending
6. Buckling and stability of rubber isolators
7. Code provisions for seismically isolated buildings

The electronic copies of the learning material will be uploaded to ILIAS and available through myStudies. The learning material includes: reading material, and (optional) exercise problems and solutions.
The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects. Does not take place this semester.

### Literature

- **Design of seismic isolated structures: from theory to practice**, Farzad Naeim and James M. Kelly, John Wiley & Sons, 1999
- **Mechanics of rubber bearings for seismic and vibration isolation**, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011
- **101-0157-01 Structural Dynamics and Vibration Problems course**, or equivalent, or consent of the instructor. Students are expected to know basic modal analysis, elastic spectrum analysis and basic structural mechanics.

### Prerequisites / notice

In this course, the students will learn:

- Critical question structural design concepts of historical and contemporary references
- Use graphic statics and strut-and-tie models based on the Theory of Plasticity to describe the load bearing behavior of structures
- Understand different construction technologies and have an awareness of their potential for structural design
- Use contemporary digital tools for the design of structures in equilibrium
- Design an appropriate structural system for a given design task taking into account architectural considerations

The goal of the course is to introduce the civil engineering students to Structural Design, which is understood as a discipline that relates structural behavior, construction technologies and architectural concepts. Hence, the course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects, in which the static and architectural aspects come together. The course is structured in two main parts, each developed in half of a semester: a mainly theoretical one (including the teaching of graphic statics) and a mainly applied one (focused on the development of a design project by the students using digital form-finding tools).

Theory:

Graphic statics is a graphical method developed by Prof. Karl Culmann and firstly published in 1864 at ETH Zurich. In this approach to structural analysis and design, geometric construction techniques are used to visualize the relation between the geometry of a structure and the forces acting in and on it, represented by geometrically dependent form and force diagrams.

The course will firstly review the main principles of graphic statics through a series of frontal lectures and discuss the relationship to analytical statics. Graphic statics is then used as an operative tool to design structures in equilibrium based on the lower bound theorem of the Theory of Plasticity. Additionally, the course will introduce contemporary methodologies and tools (parametric CAD software) for the interactive application of equilibrium modelling in the form of short workshops. The students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

Design Project:

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students’ ability to integrate architectural considerations into their structural design.

### Content

**Laboratory fatigue and fracture tests on details with cracks.**

- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

### Objective

After successfully completing this course the students will be able to:

1. Critically question structural design concepts of historical and contemporary references
2. Use graphic statics and strut-and-tie models based on the Theory of Plasticity to describe the load bearing behavior of structures
3. Understand different construction technologies and have an awareness of their potential for structural design
4. Use contemporary digital tools for the design of structures in equilibrium
5. Design an appropriate structural system for a given design task taking into account architectural considerations

The course will firstly review the main principles of graphic statics through a series of frontal lectures and discuss the relationship to analytical statics. Graphic statics is then used as an operative tool to design structures in equilibrium based on the lower bound theorem of the Theory of Plasticity. Additionally, the course will introduce contemporary methodologies and tools (parametric CAD software) for the interactive application of equilibrium modelling in the form of short workshops. The students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

**Design Project:**

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students’ ability to integrate architectural considerations into their structural design.

### Literature

**“Faustformel Tragwerksentwurf”**

(Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2015, ISBN 978-3-421-04012-1)

**“Form and Forces: Designing Efficient, Expressive Structures”**


**“The art of structures, Introduction to the functioning of structures in architecture”**

The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings; multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Elastic-plastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and "Laboratory Competition". The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- "Laboratory Competition" at Empa: the students with the closest predictions will win the "Empa Laboratory Competition" and will be awarded by a prize.

Lecture notes
Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Literature

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0169-00L</td>
<td>Timber Structures III</td>
<td>W</td>
<td>3</td>
<td>A. Frangi, R. Jockwer, M. Klippel, S. M. Schoenwald, R. Steiger</td>
</tr>
<tr>
<td>101-0120-00L</td>
<td>Structural Glass Design and Facade Engineering</td>
<td>W</td>
<td>3</td>
<td>V.-A. Silvestru</td>
</tr>
</tbody>
</table>

Abstract
Consolidation and supplementation of the basic knowledge acquired in Timber Structures I + II. Treatment of current topics and innovations in timber engineering, Structural design and refurbishment of complex timber structures with high requirements for earthquake resistance, sound insulation and fire protection. Description, analysis and discussion of an existing timber structure in groups.

Objective
In-depth understanding of the theoretical and design aspects of timber construction. Dimensioning, structural design, optimisation and refurbishment of complex timber structures with high requirements for earthquake resistance, sound insulation and fire protection.

Content
Multi-storey timber buildings (general, cross laminated timber, high-rise buildings, fire protection, sound insulation), Post-tensioned timber constructions, building with hardwood, robustness of timber structures, earthquake-resistant timber structures, maintenance and renovation of structures.
This course introduces civil engineering students to structural glass design and related facade engineering aspects. It aims to provide the students with the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection mechanical elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent facades;
- Requirements and functions for transparent facades.

Design exercises:
The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Design project:
The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass facade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

Lectures:
The lectures are based on lecture slides and handouts.

Literature:
Recommended and supplementary literature:

Prerequisites / notice:
Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

101-0139-00L
Scientific Machine and Deep Learning for Design and Construction in Civil Engineering

Abstract:
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

Objective:
Upon completion of the course, the students will be able to:
1. understand main ML background theory and methods
2. assess a problem and apply ML and DL in a computational framework accordingly
3. Incorporating scientific domain knowledge in the SciML process
4. Define, Plan, Conduct and Present a SciML project

Content:
The course will include theory and algorithms for SciML programming assignments, as well as a final project assessment.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a “hands-on” feel for the course topics.

Lecture notes:
The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Literature:
Suggested Reading:
- Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016

Prerequisites / notice:
Familiarity with MATLAB and / or Python is recommended.

Major in Transport Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0469-00L</td>
<td>Road Safety</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>M. Deublein, P. Eberling</td>
</tr>
</tbody>
</table>

Abstract:
The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

Objective:
Importing knowledge about road safety and the event of accident, presenting possibilities to increase road safety

Content:
Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for focus on road safety audit, Swiss and international transport policy

Literature:

Further literature: will be presented during the course.
Methodology of Planning Research and Practice  W  3 credits  2G  A. Peric Momcilovic, T. Hug, R. Streit

Abstract
This course deals with scientific and applied methods and the ways of thinking that are useful in planning practice as well as in scientific research. Students are offered interdisciplinary knowledge from planning practice and research, behavioural economics and social sciences. New perspectives on planning are opened up, which can lead to better results in future projects and research.

Objective
Keeping the general aim of exploring the basic methodologies in spatial planning research and practice, the specific course learning objectives are as follows:
- to address complex real-world spatial problems in adequate ways
- to know relevant theories and maxims that are subject to specific methods of problem solving
- to identify key questions and key concepts in contemporary planning research
- to select appropriate research methods to properly address the research questions

In practical terms, students:
- learn to deal with uncertainties and estimate quantities
- improve their ability to take decisions based on incomplete data and information
- are informed about different (qualitative and quantitative) methods and techniques for spatial research
- learn about different types of research (theoretical, empirical, action-oriented, qualitative, quantitative)
- get skilled for writing simple research essays
- are urged to question their own knowledge and challenge the course of action taken in planning processes

Content
The course is based on the following questions:

How do we deal with complex issues in planning?
- Forms of knowledge, half-knowledge and not knowing
- Occurrence and explanation patterns for irrational behaviour
- Spatial research and planning practice
- Planning maxims
- Mapping complex topics in research questions

How do we generate knowledge about complex issues?
- Methods for scientific data generation
- Applied handling of quantities and probabilities
- Estimating despite uncertainties
- Opportunities of digitalisation in planning (Participation, BigData)

How do we react to complex questions in planning?
- Methods of scientific data analysis
- Making decisions despite incomplete information
- Dealing with robustness and fragility

More specifically, the lectures focus on the following topics (NB: Some content units will be presented in English, they are marked with *asterisk below)
- (Half-) knowledge/behaviour/irrationailities
- Initial situation: Solving complex problems
- Forms of knowledge, knowing of not knowing something, not knowing of not knowing something
- Behavioural patterns, occurrence and explanation patterns for irrational behaviour
- Methods for solving complex tasks in planning practice
- Spatial research and planning practice - connections, differences, overlaps
- Challenges in the solution of complex tasks: System delimitation, interdisciplinarity, retrospective vs. prospective approach (descriptive vs. action-oriented, *reflected scenario building*)
- Planning maxims
- *Methodology in spatial research
- *Research design
- *Research questions (types of research questions; research questions, hypotheses and theories); justification of research question
- Data generation methods (interviews and questionnaires, ethnography and observation, documents, official statistics)
- Dealing with quantities, estimations, anchor effect
- Importance of scales and key figures in planning
- Estimation methods
- Danger of the anchor effect
- Digitization in planning
- New data sources and sizes
- Opportunities and challenges through digitalisation in planning
- Data analysis methods (quantitative and qualitative data; quantitative analysis of survey data; qualitative analysis - content analysis, discourse analysis, case study, comparative research)
- *Research ethics
- Decisions based on incomplete information
- Dealing with complex systems/roughness
- *Role of science in planning - the perspective of both research and practice

Lecture notes
Learning materials: available online (Moodle) before corresponding lecture.

Literature
The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize

### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Negotiation</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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### Content

This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn

1. Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2. Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3. Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open-source eqasim framework used at ETH Zurich to set up agent-based models will be introduced
4. Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

DURING THE COURSE, OUTSIDE LECTURERS WILL GIVE SEVERAL LECTURES ON USING MATSIM IN PRACTICE (I.E., SBB).

### Literature

- MATSim

### Prerequisites / notice

There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

### 101-0491-00L Agent Based Modeling in Transportation

**Abstract**

This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn

- about agent-based models’ current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

- setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open-source eqasim framework used at ETH Zurich to set up agent-based models will be introduced

- conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

- during the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

### 101-0492-00L Microscopic Modelling and Simulation of Traffic

**Abstract**

The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development,

- calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies.

- the aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.

- the objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network.

- throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

- simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

- upon completion of the course, the students will:

  1. Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
  2. Design a road transport network inside the simulation software.
  3. Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
  4. Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
  5. Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.
In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:

1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:

1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

The lecture notes and additional handouts will be provided before the lectures.

A list with related technical literature will be handed out.

The slides will be made available.

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The lecture notes and additional handouts will be provided before the lectures.

A list with related technical literature will be handed out.

The slides will be made available.
This course provides an introduction to object-oriented programming with Java. Four topics are covered:
- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods,...)
- Injection (traditional vs. Guice)
- Code versioning
- Java application deployment on servers

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**Major in Hydraulic Engineering and Water Resources Management**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0249-00L</td>
<td>Hydraulic Engineering: Selected Topics</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>R. Boes</td>
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<tr>
<td></td>
<td>Does not take place this semester. Prerequisites: 101-0247-01L Hydraulic Engineering II or equivalent course</td>
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<tr>
<td>Abstract</td>
<td>The lecture focuses on selected topics in hydraulic engineering, water management and aquatic ecology relating to hydropower and flood protection projects.</td>
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<tr>
<td>Objective</td>
<td>The overarching goal of the course is to deepen knowledge on special aspects in hydraulic engineering and to understand the procedures and the planning sequence of hydropower projects.</td>
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<tr>
<td>Content</td>
<td>Different selected topics in hydraulic engineering will be focused on, e.g. dam safety, materials in dam building, possible problems at reservoirs like natural hazards by impulse waves, the hydraulics of spillways and intake structures at dams and weirs and the area of conflict between hydropower and ecology. Another focus will be put on typical approaches and procedures in the planning process of hydropower projects at the national and international level.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Lecture notes will be available online.</td>
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</tr>
<tr>
<td>Literature</td>
<td>External speakers will be involved to present current topics and projects in Switzerland and abroad.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td></td>
<td></td>
<td>Techniques and Technologies</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
<td>Critical Thinking</td>
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<td></td>
<td>Self-direction and Self-management</td>
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<tr>
<td>101-0289-00L</td>
<td>Applied Glaciology</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>D. Farinotti, A. Bauder, M. Werder</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.</td>
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<tr>
<td>Objective</td>
<td>The objectives of the courses are to:</td>
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<td></td>
<td>- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;</td>
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<td>- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;</td>
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<td></td>
<td>- generate the own computer code to solve the above case studies, and interpret the results;</td>
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<td></td>
<td>- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.</td>
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<tr>
<td>Content</td>
<td>The course will develop along the following outline:</td>
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<td>- How glaciology became a scientific discipline</td>
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<td>- Glaciology and hydropower</td>
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<td>- Glacier mechanics and ice flow</td>
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<td>- Gravitational glacier instabilities</td>
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<td>- Glacier hydrology and glacier lake outbursts</td>
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<td></td>
<td>- Lake ice and ice bearing capacity</td>
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<td>- Field excursion to Jungfraujoch</td>
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<td></td>
<td>- Discussion of the exercises performed during the semester</td>
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<tr>
<td>Lecture notes</td>
<td>Digital lecture handouts will be distributed prior to each class.</td>
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<tr>
<td>Literature</td>
<td>Links to relevant literature will be provided during the classes.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Completed BSc studies. Basic knowledge in computer scripting in any language (e.g. Python, R, Julia, Matlab, IDL,...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.</td>
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<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Method-specific Competencies</td>
<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Customer Orientation</td>
<td>assessed</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td>Creative Thinking</td>
<td>assessed</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
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**Hydraulics of Engineering Structures**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>101-1249-00L</td>
<td>Hydraulics of Engineering Structures</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>I. Albayrak, F. Evers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Hydraulic fundamentals are applied to hydraulic structures for wastewater, flood protection and hydropower. Typical case studies from engineering practice are further described.</td>
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</table>
Objective

Understanding and quantification of fundamental hydraulic processes with particular focus on hydraulic structures for wastewater, flood protection and hydropower.

In the course "Hydraulics of Engineering Structures", the competencies of process understanding, system understanding and measurement methods are taught, applied and examined. The competencies modeling, concept development and data analysis & interpretation are taught and data analysis & interpretation is applied in addition.

Content

1. Introduction & Basic equations
2. Losses in flow & Maximum discharge
3. Uniform flow & Critical flow
4. Hydraulic jump & Stillling basin
5. Backwater curves
6. Weirs & End overfall
7. Sidewier & Side channel
8. Bottom opening, Venturi & Culverts, Restrictors, Inverted siphons
9. Fall manholes & Vortex drop
10. Supercritical flow & Special manholes
11. Aerated flows & Low level outlets
12. Hydraulics of sediment bypass tunnels
13. Vegetated flows - Introduction & Application
14. Summary

Lecture notes

Text books


Literature

Exhaustive references are contained in the suggested text book.

102-0215-00L Urban Water Management II W 4 credits 2G M. Maurer, P. Staufer

Abstract


Objective

Consolidation of the basic procedures for design and operation of technical networks in water engineering.

Content

Demand Side Management versus Supply Side Management
Optimierung von Wasserverteilnetzen
Kalkaussäufung, Korrosion von Leitungen
Hygiene in Verteilsystemen
Siedlungshydrologie: Niederschlag, Abflussbildung
Instationäre Strömungen in Kanalisationen
Stofftransport in der Kanalisation
Einleitung bei Regenwetter
Versickerung von Regenwasser
Generelle Entwässerungsplanung (GEP)

Lecture notes

Written material will be available digital.

Prerequisites / notice

Prerequisite: Introduction to Urban Water Management

Fostered competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies

Communication
Cooperation and Teamwork
Customer Orientation
Self-presentation and Social Influence
Sensitivity to Diversity

Personal Competencies

Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

101-1250-00L Management of Hillslope and Channel Processes W 3 credits 2V D. Rickenmann

Abstract


Objective

Ziel

To recognise and understand channel and hillslope processes and their interactions. To learn about methods of hazard analysis and of technical and bioengineering protection measures and their assessment. Determination of critical loads and design of protective structures. Assessment of spatial and future developments with and without protective measures.

Content

Inhalt


Lecture notes

see "Literatur"

Literature

Prerequisites / Requirements:
- Essentials of Construction Analysis
- Hydraulics
- Geology and Petrography
- Soil Physics
- Soil Mechanics and Geotechnics

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
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- Leadership and Responsibility
- Self-presentation and Social Influence
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- Negotiation

Personal Competencies
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- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Major in Materials and Mechanics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>101-0639-01L</td>
<td>Science and Engineering of Glass and Natural Stone in Construction</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
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</tbody>
</table>

Does not take place this semester.

Abstract
The course offers an overview of relevant practical issues and present technological challenges for glass and natural stones in constructions. Students gain a good knowledge of the basics of glasses and natural stones, their potential as engineering materials and learn to apply them in the design of civil engineering constructions and to evaluate concepts.

Objective
Glass is increasingly used in constructions to ease the construction process, as functional insulation barrier, even for structural applications of impressive size. While everyone has experienced the innovation potential of glass in the last decade, products from natural stone suffer from an unjustified traditional image that often originates from a lack of understanding of the material and its combination with other materials. Culturally important structures often are made from natural stone and their conservation demands an understanding of their deterioration mechanisms, the concepts of which can be applied to other civil engineering materials. Designers and engineers need the knowledge to reconcile materials and system behavior with the entire processing, handling, integration and life time in mind.

In this module students are provided with a broad fundamental as well as practice-oriented education on glass and natural stone in civil engineering applications. Present and future construction and building concepts demand for such materials with optimized properties. Based on the fundamentals from the Bachelor course in materials by the end of this module, you should be able to:

- recognize and choose specific applications from the broad overview you were provided with,
- relate processing technologies to typical products and building applications and recognize (and explain typical damage related to wrong material choice or application,
- explain the nature of glassy and crystalline materials and interpret their physical behavior against this background,
- explain the major deterioration mechanisms in natural stone and how this relates to durability,
- analyze material combinations and appraise their application in future products as well as integration in existing constructions,
- summarize with appropriate guidance publications on a related topic in an oral presentation and short report.
Content

Lecture 1: An introduction to science and engineering of glass and natural stone in construction (FW/TW)

Lecture 2: Glass chemistry including historical development of glass composition, use of raw materials, melts, chemical stability and corrosion. (FW)

Lecture 3: Geology and mineralogy of stones used in construction. Formation processes, chemistry, crystal structure. (TW)

Lecture 4: Microscopic models for glassy materials. Physics of vitrification. From microscopic physical models to thermodynamics, rheology and mechanics of glassy materials. (FW)

Lecture 5: Stone properties and behavior: microstructure, density, porosity, mechanical properties (TW)

Lecture 6: Glass physics: Optical properties (transmission, reflection, emission, refraction, polarization and birefringence, testing methods); Mechanical properties (density, thermal, mechanical, electric properties, glass testing) (FW)

Lecture 7: Stone properties and durability: transport, moisture and thermal cycling (TW)

Lecture 8: Forming and processing of glass: (plate and molded glass, drawing, slumping, profiling etc.; Processing: Cutting, mechanical processing, tempering, gluing, bending, laminating of glass Surface treatments: coating, sputtering, enameling, printing, etching, chemical pre-stressing.) (FW)

Lecture 9: Durability: Salt crystallization, freezing, biodeterioration (TW)

Lecture 10: Glass products for civil engineering applications: (Molded glasses, fiber glass, foam glass, plate glass); construction glass (insulation glass, structural glass, protective glass, intelligent glass, codes); (FW)

Lecture 11: Conservation: Consolidation, cleaning, and other treatments (TW).

Lecture 12: Glass in constructions. (modelling, application and regulation, typical damage in glass) (FW)

Lecture 13: Student presentations; exam questions (FW/TW)

Lab1: Durability of natural stone (FW/TW)

Lab2: Fracture of glass (FW/TW)

Lecture notes

Will be handed out in the lectures

Literature

Werkstoffe II script (download via the IFB homepage). Rest will be handed out in the lectures

Prerequisites / notice

Werkstoffe I/II of the bachelor studies or equivalent introductory materials lecture.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
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<td>Techniques and Technologies</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Critical Thinking</td>
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<td>Self-direction and Self-management</td>
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101-0659-01L

Durability and Maintenance of Reinforced Concrete   W   4 credits   2V   U. Angst, Z. Zhang

Abstract

We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.

Objective

After this course you will have profound understanding about:

- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:

- current engineering approaches for durability design (according to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- preventive measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies
Shrinkage and Cracking of Concrete: Mechanisms and Impact on Durability

Concrete is generally viewed as a durable construction material. However, the long-term performance of a concrete structure can be greatly compromised by early-age cracking. This course will explain how shrinkage of concrete leads to cracking and how control of shrinkage allows increasing the expected durability of a concrete structure.

In addition to macroscopic cracks, microcracking may occur in the cement paste due to inner restraint offered by the aggregates. Both macroscopic cracks and diffuse microcracking within a concrete may facilitate the ingress of harmful substances (e.g. chloride and sulfate ions) into the concrete; these may react with the concrete or with the reinforcement and create further deterioration. The students will learn the main causes of cracking at early ages, namely plastic, drying, thermal and autogenous shrinkage, with special emphasis on the driving mechanisms. The importance of concrete curing, especially in the first few days after casting, will be stressed and explained. Building on the knowledge of the driving forces of shrinkage, the way of action of shrinkage-reducing admixtures will be clarified and different applications illustrated. As an extension of external curing, the students will become familiar with internal water curing by means of saturated lightweight aggregates and superabsorbent polymers. Most concrete members are restrained by adjacent structures. When shrinkage is restrained, cracks may develop. The students will learn how to apply different criteria for assessing concrete cracking and how to retrieve the mechanical properties of the concrete, especially stiffness and creep, which are needed for the calculations of self-induced stresses and risk of cracking.

As a final outcome of the course, the students will be able to estimate the impact of cracking on the expected durability of concrete structures and to implement different types of measures to reduce the extent of cracking.
Concrete is generally viewed as a long-lasting construction material. However, the durability of a concrete structure can be jeopardized by shrinkage-induced cracking. In addition to being unsightly, cracks have the potential to act as weak planes for further distress or as conduits for accelerated ingress of aggressive agents that may reduce durability.

Advances in concrete technology over the past decades have led to the practical use of concrete with a low water to binder ratio and with different types of mineral and organic admixtures. Another recent development is self-compacting concrete, which avoids concrete vibration and reduces labor during placing. Unfortunately, these concretes are especially prone to cracking at early ages, unless special precautions are taken. Proper curing becomes in this case the key to achieve better performance in various environmental and load conditions.

### Specific topics covered by the course:

- Hydration and microstructure development
- Plastic shrinkage
- Development of mechanical properties
- Thermal deformation
- Autogenous deformation
- Drying shrinkage
- Creep and relaxation
- Curing
- Shrinkage-reducing admixtures
- Internal curing: saturated lightweight aggregates and superabsorbent polymers
- Fracture and microcracking
- Transport in cracked concrete
- Impact of cracking on concrete durability
- Self-healing of cracks

### Literature

Copies of one to two research papers relevant to the topic of each lecture will be provided to the students as supportive information.

### Prerequisites / notice

A basic knowledge of concrete technology is preferable.

### 101-0637-10L Wood Structure and Function

**Abstract**

The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general and species-specific relationships between growth processes, wood properties and wood function in the living tree.

**Objective**

Learning target is a basic understanding of the anatomy of wood and the related impact of endogenous and exogenous factors. The course will illustrate how to distinguish common central European wood species at the macroscopic and microscopic level. A deeper insight will be given by wood identification exercises for softwood species. Further, the students will gain insight into the relationships between tree growth and wood properties with a specific focus on the wood function in the living tree.

**Content**

In an introduction to wood anatomy, the general structural features of softwoods and hardwoods will be explained and factors of diversity and variability will be discussed. A specific focus is laid on common central European tree species with relevance in the wood sector, which will be studied in macro- and microstructural investigations. In the following, relationships between wood structure, properties and function in the living tree will be the focus of the lectures. Topics covered are water transport, trends in wood anatomy within trees, environmental impact on wood anatomy, wood defects and their causes, tools to study wood properties over time, secondary changes in wood, and tree biomechanics.

### 101-0637-20L Fundamentals of Wood Elaboration and Woodmachining

**Abstract**

The course Wood processing conveys knowledge on technological properties of wood and wood-based materials as well as on industrial processes for the fabrication of a vast variety of wood products and covers new developments in the field of digital technologies.

**Objective**

Learning target is a fundamental understanding of the dominating wood machining processes, which are applied to fabricate common wood products. Students will be introduced to the economic relevance of the renewable resource wood and are trained in its technological properties. The students will learn to identify the relationships between wood species and their properties as well as the suitable wood machining processes to fabricate targeted wood products. Finally, the digital transformation process, which will affect all sectors of the wood-industry with impact on the entire value chain and business models will be covered. It will be illustrated how production processes will become more flexible, efficient and less resource demanding.

**Content**

The general introduction shows the economic relevance of the resource wood in a global, European and Swiss context and reflects aspects of sustainability in wood production and certification. In terms of bulk wood products a specific focus is laid on sawn timber production and drying processes. With regard to wood veneer production, steaming, veneer cutting and assembly to veneer lumber products are presented. Further the common technologies for the production of particle boards and fibre boards as well as paper will be discussed. In the following, the topics are related to wood gluing and wood protection as well as potentials and limitations in the application of wood and wood-based products. In a further part, the lecture deals with the most important digital technologies, e.g. Internet of Things, artificial intelligence and their impact on the wood industry on the basis of illustrative examples. At the end of the lecture an excursion to a Swiss wood manufacturer is planned, in order to facilitate practical experience.

### 101-0159-00L Method of Finite Elements II

**Abstract**

The Method of Finite Elements II is a continuation of Method of Finite Elements I. Here, we explore the theoretical and numerical implementation concepts for the finite element analysis beyond the linear elastic behavior. This course aims to offer students with the skills to perform nonlinear FEM simulations using coding in Python.

*This course offers no introduction to commercial software.

**Objective**

This class overviews advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to excessive loading effects and energy dissipation mechanisms. Their understanding is necessary for reliably computing structural capacity. In this course, instead of blindly using generic structural analysis software, we offer an explicit understanding of what goes on behind the curtains, by explaining the algorithms that are used in such software.

The course specifically covers the treatment of the following phenomena:

- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:

- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems.

See the class webpage for more information:


**Lecture notes**

The course slides serve as Script. These are openly available on: http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html
Useful (optional) Reading:

Prerequisites / notice
Prerequisites:
- 101-0158-01 Method of Finite Elements I (FS)
- A good knowledge of Python is necessary for attending this course.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Problem-solving
Method-specific Competencies
- Cooperation and Teamwork
Personal Competencies
- Creative Thinking
- Critical Thinking

Projects

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<tr>
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<td>W</td>
<td>11 credits</td>
<td>24A</td>
<td>Supervisors</td>
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<td>Abstract</td>
<td>Working on a concrete task in Construction Engineering</td>
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<tr>
<td>Objective</td>
<td>Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.</td>
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<tr>
<td>Content</td>
<td>The project work is supervised by a professor. Students can choose from different subjects and tasks.</td>
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<tr>
<td>101-0298-10L</td>
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<td>24A</td>
<td>Supervisors</td>
</tr>
<tr>
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<tr>
<td>101-0398-10L</td>
<td>Project on Geotechnical Engineering</td>
<td>W</td>
<td>11 credits</td>
<td>24A</td>
<td>Supervisors</td>
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<td>Objective</td>
<td>Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.</td>
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<tr>
<td>101-0698-10L</td>
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<td>W</td>
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Digitalisation Specific Courses

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<tr>
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<tr>
<td>101-0317-00L</td>
<td>Tunnelling I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Anagnostou, A. Nordas, E. Pimentel</td>
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<tr>
<td>Objective</td>
<td>Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.</td>
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</table>
The lecture notes and additional handouts will be provided during the lectures.

Analytical Competencies
The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

S. Marelli

Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro- codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FORM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

Prerequisites / notice
Basic course on probability theory and statistics

101-0417-00L Transport Planning Methods W 6 credits 4G K. W. Axhausen

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

101-0437-00L Traffic Engineering W 6 credits 4G S. Mousavi, M. Makridis

Abstract
Fundamentals of traffic flow theory and control.

Objective
The objective of this course is to fully understand the fundamentals of traffic flow theory in order to effectively manage traffic operations. By the end of this course students should be able to apply basic techniques to model different aspects of urban and inter-urban traffic performance, including congestion.

Content
Introduction to fundamentals of traffic flow theory and control. Includes understanding of traffic data collection and processing techniques, as well as data analysis, traffic modeling, and methodologies for traffic control.

Lecture notes
The lecture notes and additional handouts will be provided during the lectures.

Literature
Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)

Prerequisites / notice
Special permission from the instructor can be requested if the student has not taken Verkehr III

Data: 01.11.2022 12:41
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

**Method of Finite Elements II**

This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

**Objective**

At the end of the course, the students should:
- have an understanding of agent-based modeling
- have an understanding of MATSim
- have an understanding of the process needed to set up an agent-based study
- have practical experience of using MATSim to perform practical transportation studies

**Content**

This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open-source eqasim framework used at ETH Zurich to set up agent-based models will be introduced
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

**Literature**

Agent-based modeling in general


**MATSIm**


Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

**Prerequisites / notice**

There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.

**Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.**
This class overviews advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to excessive loading effects and energy dissipation mechanisms. Their understanding is necessary for reliably computing structural capacity. In this course, instead of blindly using generic structural analysis software, we offer an explicit understanding of what goes on behind the curtains, by explaining the algorithms that are used in such software.

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems.

See the class webpage for more information:

Useful (optional) Reading:

Prerequisites / notice
-101-0158-01 Method of Finite Elements I (FS)
- A good knowledge of Python is necessary for attending this course.

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Problem-solving
-101-0617-02L Computational Science Investigation for Material Mechanics
4 credits
2S
W
D. Kammer, F. Wittel

Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various models.

Objective
Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can often only be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content
1 Introduction to (numeric) forensic engineering
2 The nature of engineering problems (governing equations)
3 Numerical recipes for dealing with non-linear problems
4 Multi-field problems (HTM)
5 On the nature of failure - Physics of damage and fracture
6 Cracks and growth in structures (LEFM and beyond)
7 Fracture Mechanics
8 Damage and fracture in heterogeneous materials
9 Mechanics of fatigue
10 Visco-elastic failure
11 Student - Project presentation

Lecture notes
Will be provided during the lecture via moodle.

Literature
Will be provided during the lecture.

Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Problem-solving

Method-specific Competencies
Techniques and Technologies
Decision-making

Social Competencies
Communication

Personal Competencies
Adaptability and Flexibility

Creative Thinking
Critical Thinking

Integrity and Work Ethics
Self-direction and Self-management

101-0185-01L CAD for Civil Engineers

W
2 credits
2G
F. Ortíz Quintana, M. Miani

Number of participants is limited to 30. Point in time of enrolment of course is decisive.

Abstract
Introduction to computer aided design and drafting in 2D and 3D with examples from structural engineering.
This course aims to provide graduate level introduction into Machine and especially scientific Machine Learning for applications in the natural and engineered systems. When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performing algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.
Objective

After successful completion of the course, students will be able to:

- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;
- Recognize requirements for glass elements depending on their application area and choose the appropriate glass products and assemblies accordingly;
- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;
- Apply selected approaches for the structural design of in-plane loaded glass elements;
- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.

Content

This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:

- Properties and design of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent facades.

Design exercises:
The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design S.J. Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Design project:
The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

Prerequisites / notice

Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.

Literature

Recommended and supplementary literature:


Lecture notes

The lectures are based on lecture slides and handouts.

Infrastructure Management 1: Process

W 6 credits 2G B. T. Adey

Infrastructural asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods of time. This course provides an overview of the process, from setting goals to developing intervention programs to analyzing the process itself. It consists of weekly lectures and a group project. Additionally, there is a weekly help session.

Objective

There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines have focused on only part of the large complex problem of infrastructure asset management.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clear understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will:

- understand the main tasks of an infrastructure manager and the complexity of these tasks,
- understand the importance of setting goals and constraints in the management of infrastructure,
- be able to predict the deterioration of individual assets using discrete states that are often associated with visual inspections,
- be able to develop and evaluate simple management strategies for individual infrastructure assets,
- be able to develop and evaluate intervention programs that are aligned with their strategies,
- understand the principles of guiding projects and evaluating the success of projects,
- be able to formally model infrastructure management processes, and
- understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.
The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.
Objective

The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g., creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:

1. Car following models
2. Lane change models
3. Calibration and validation methodology

Specific tasks for the project will include:

1. Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2. Calibrating and validating the simulation model.
3. Redesigning/extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and present) across the semester. A midterm and final presentation of the work will be asked from each group of students.

It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Lecture notes

The lecture notes and additional handouts will be provided before the lectures.

Additional literature recommendations will be provided at the lectures.

Prerequisites / notice

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed

Social Competencies
- Cooperation and Teamwork: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

101-0123-00L Structural Design

Abstract

The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects.

Objective

After successfully completing this course the students will be able to:
1. Critically question structural design concepts of historical and contemporary references
2. Understand different construction technologies and have an awareness of their potential for structural design
3. Use contemporary digital tools for the design of structures in equilibrium
4. Design an appropriate structural system for a given design task taking into account architectural considerations

Content

The goal of the course is to introduce the civil engineering students to Structural Design, which is understood as a discipline that relates structural behavior, construction technologies and architectural concepts. Hence, the course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects, in which the static and architectural aspects come together. The course is structured in two main parts, each developed in half of a semester: a mainly theoretical one (including the teaching of graphic statics) and a mainly applied one (focused on the development of a design project by the students using digital form-finding tools).

Theory:

Graphic statics is a graphical method developed by Prof. Karl Culmann and firstly published in 1864 at ETH Zurich. In this approach to structural analysis and design, geometric construction techniques are used to visualize the relation between the geometry of a structure and the forces acting in and on it, represented by geometrically dependent form and force diagrams.

The course will initially review the main principles of graphic statics through a series of frontal lectures and discuss the relationship to structural behavior, construction technologies and architectural concepts. Hence, the course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects, in which the static and architectural aspects come together. The course is structured in two main parts, each developed in half of a semester: a mainly theoretical one (including the teaching of graphic statics) and a mainly applied one (focused on the development of a design project by the students using digital form-finding tools).

Design Project:

Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students' ability to integrate architectural considerations into their structural design.
### Literature

- "Faustformel Tragwerksentwurf"  
  (Philippe Block, Christoph Gengangel, Stefan Peters,  

- "Form and Forces: Designing Efficient, Expressive Structures"  

- "The art of structures, Introduction to the functioning of structures in architecture"  

### 102-0468-10L Watershed Modelling

#### Abstract
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

#### Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

#### Content
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

#### Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

#### Literature
Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

#### Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

#### Fostered competencies

<table>
<thead>
<tr>
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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
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<td>Critical Thinking</td>
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<td>Decision-making</td>
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<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>Self-direction and Self-management</td>
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### 101-0121-00L Fatigue and Fracture in Materials and Structures

**Does not take place this semester.**

#### Abstract
The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

#### Objective
In this course, the students will learn:
- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.
This course provides an introduction to programming in Java, version control, and cloud computing. Infrastructure asset management is the process used to ensure that infrastructure provides adequate levels of service for specified periods.

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using the (student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and "Laboratory Competition". The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- "Laboratory Competition" at Empa: the students with the closest predictions will win the "Empa Laboratory Competition" and will be awarded a prize.

Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

**Content**
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The primary topics that are covered in this course are:


**Abstract**
This course provides an introduction to programming in Java, version control, and cloud computing.

**Objective**
At the end of the course, the students should:
- Have acquired object-oriented programming skills with a focus on Java.
- Have an understanding of version control using git.
- Have learned to deploy Java applications on servers.

**Content**
This course provides an introduction to object-oriented programming with Java. Four topics are covered:
- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods, ...).
- Injection (traditional vs. Guice).
- Code versioning.
- Java application deployment on servers.

**Literature**
Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

**Project Based Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0491-10L</td>
<td>Basics of Java and Best Practices for Scientific Computing</td>
<td></td>
<td></td>
<td></td>
<td>M. Balac</td>
</tr>
<tr>
<td>401-0647-000L</td>
<td>Introduction to Mathematical Optimization</td>
<td></td>
<td></td>
<td></td>
<td>D. Adjaishvili</td>
</tr>
</tbody>
</table>

*Note: This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.*
There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines and much of the research, however, are focused on only part of the large complex problem of infrastructure asset management.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clear understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will
- understand the main tasks of an infrastructure manager and the complexity of these tasks,
- understand the importance of setting goals and constraints in the management of infrastructure,
- be able to predict the deterioration of individual assets using discrete states that are often associated with visual inspections,
- be able to develop and evaluate simple management strategies for individual infrastructure assets,
- be able to develop and evaluate intervention programmes that are aligned with their strategies,
- understand the principles of guiding projects and evaluating the success of projects,
- be able to formally model infrastructure management processes, and
- understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.

The weekly lectures are structured as follows:
1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.
2. Positioning infrastructure management in society: As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.
3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.
4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.
5. Help session 1
6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.
7. Determining and justifying monitoring - Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.
8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.
9. Help session 2
10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.
11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.
12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.
13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.
14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

The lecture materials consist of handouts, the slides, and example calculations in Excel.

The lecture materials will be distributed via Moodle two days before each lecture.

Appropriate literature will be handed out when required via Moodle.

This course has no prerequisites.
The overarching goal of the course is to deepen knowledge on special aspects in hydraulic engineering and to understand the procedures and the planning sequence of hydropower projects.

Lecture notes will be available online.

R. Boes

Hydraulic Engineering: Selected Topics

101-0249-00L

Abstract

The lecture focuses on selected topics in hydraulic engineering, water management and aquatic ecology relating to hydropower and flood protection projects.

Objective

The overarching goal of the course is to deepen knowledge on special aspects in hydraulic engineering and to understand the procedures and the planning sequence of hydropower projects.

Content

Different selected topics in hydraulic engineering will be focused on, e.g. dam safety, materials in dam building, possible problems at reservoirs like natural hazards by impulse waves, the hydraulics of spillways and intake structures at dams and weirs and the area of conflict between hydropower and ecology. Another focus will be put on typical approaches and procedures in the planning process of hydropower projects at the national and international level.

Lecture notes will be available online.

Literature

External speakers will be involved to present current topics and projects in Switzerland and abroad.

Fostered competencies

| Subject-specific Competencies | Concepts and Theories | assessed |
| Method-specific Competencies | Analytical Competencies | assessed |
|                             | Decision-making        | assessed |
|                             | Media and Digital Technologies | assessed |
|                             | Problem-solving        | assessed |
| Project Management          | assessed               |

Social Competencies

Communication not assessed

Cooperation and Teamwork not assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence not assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Adaptability and Flexibility not assessed

Creative Thinking not assessed

Critical Thinking not assessed

Integrity and Work Ethics not assessed

Self-awareness and Self-reflection not assessed

Self-direction and Self-management not assessed

Design-Integrated Life Cycle Assessment

101-0608-00L

Abstract

Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process. The aim of this course is to apply LCA during the design of buildings by means of a digital, parametric tool. The necessary fundamentals of the LCA method will be taught following a lecture on demands approach.

Objective

The course will follow two main objectives and a third optional objective, depending on the design projects the students' choose. At the end of the course, the students will:

1. Know the methodology of LCA
2. Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
3. Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation

Content

The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand

The first six individual courses will follow the "lectures on demand" approach. Small "hands-on" exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:

1) LCA basic introduction
2) System boundaries, functional unit, end of life
3) Carbon budget and LCA benchmarks
4) BIM-LCA, available calculation tools and databases
5) Integrated analysis of environmental and cost assessment
6) Bio-based carbon storage

Part II: Project-based learning

In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:

1) Introduction to Rhinoceros 6 and 7
2) Introduction to grasshopper
3) Integrated assessment tools (ladybug tools)
4) Introduction to in-house grasshopper plugin for LCA analysis

Lecture notes

As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

Literature

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.
Prerequisites / notice

Prerequisite: Sustainable construction (101-0577-00L). Otherwise a special permission by the lecturer is required.

The students are expected to work out of class as well. The course time will be used by the teachers to answer project-specific questions.

The lecture series will be conducted in English and is aimed at students of master’s programs, particularly the departments ARCH, BAUG, ITET, MAVT, MTEC and UWIS.

No lecture will be given during Seminar week.

<table>
<thead>
<tr>
<th>101-0329-00L</th>
<th>Tunnelling III</th>
<th>W</th>
<th>4 credits</th>
<th>2G</th>
<th>G. Anagnostou, E. Pimentel, M. Ramoni</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Deepen the knowledge on selected topics of underground construction as well as learning working out conceptual solutions of complex problems.</td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Lecture: Deepen the knowledge on selected topics of underground construction. Exercises: Conceptual solutions of complex problems.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Caverns; Geometry, construction methods, support. Shafts: Construction methods, support. Urban tunnelling: Boundary conditions, system choice, alignment, design. Field measurements: Principles, monitoring layout, applications, interpretation. Cut and cover tunnels: Modelling, design. Exercising conceptual solution of complex tunnelling problems based upon discussion of current tunnel cases with particularly demanding problems in small groups.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Autographieblätter</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Empfehlungen</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Prerequisite: BSc course “Tunnelling”, MSc courses “Tunnelling I” and “Tunnelling II”.</td>
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<tr>
<td><strong>Fostered competencies</strong></td>
<td>Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, assessed Method-specific Competencies: Analytical Competencies, Decision-making, Problem-solving, assessed</td>
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<thead>
<tr>
<th>101-0200-10L</th>
<th>Research-Focused Project Work</th>
<th>W</th>
<th>11 credits</th>
<th>24A</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Working on a concrete task as preparation for the master’s thesis</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The project work is supervised by a professor. The topic is going to be continued as master’s thesis.</td>
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<table>
<thead>
<tr>
<th>101-0139-00L</th>
<th>Scientific Machine and Deep Learning for Design and Construction in Civil Engineering</th>
<th>W</th>
<th>3 credits</th>
<th>4G</th>
<th>M. A. Kraus, D. Griego, R. Rust</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>This course aims to provide graduate level introduction into Machine and especially scientific Machine Learning for applications in the design and construction phases of projects from civil engineering.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Upon completion of the course, the students will be able to: 1. understand main ML background theory and methods 2. assess a problem and apply ML and DL in a computational framework accordingly 3. Incorporating scientific domain knowledge in the SciML process 4. Define, Plan, Conduct and Present a SciML project</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a “hands-on” feel for the course topics.</td>
<td></td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Familiarity with MATLAB and / or Python is advised.</td>
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<table>
<thead>
<tr>
<th>101-0357-00L</th>
<th>Theoretical and Experimental Soil Mechanics</th>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>I. Anastasopoulos, R. Herzog, E. Korre, A. Marin, M. Schneider</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>The number of participants is limited to 60 due to the existing laboratory equipment! Students with major in Geotechnical Engineering have priority. Registrations will be accepted in the order they are received.</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Overview of soil behaviour  Explanation of typical applications: reality, modelling, lab tests with transfer of results to practical examples  Consolidation theory and typical applications  Triaxial tests: consolidation &amp; shear, drained &amp; undrained response  Plasticity theory &amp; Critical State Soil Mechanics, Cam Clay  Application of plasticity theory  Introduction to physical modelling</td>
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</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 232 of 2416
Objective

(1) Extend knowledge of theoretical approaches that can be used to describe soil behaviour.
(2) Offer the opportunity to perform hands on element tests required for constitutive model calibration.
(3) Enable students to select an appropriate constitutive model and calibrate it using element test performed in the lab.
(4) Enable students to carry out FE analyses for realistic geotechnical applications.

Content

Overview of soil behaviour
Discussion of general gaps between basic theory and soil response
Stress paths in practice & in laboratory tests
Explanation of typical applications: reality, modelling, laboratory tests with transfer of results to the practical examples
Consolidation theory for incremental and continuous loading oedometer tests and typical applications in practice
Triaxial & direct shear tests: consolidation & shear, drained & undrained response
Plasticity theory & Critical State Soil Mechanics, Cam Clay
Application of plasticity theory

Introduction to physical modelling with emphasis on centrifuge modelling

Lecture notes
Printed script with web support
Exercises

Literature
https://moodle-app2.let.ethz.ch/

Prerequisites / notice

Pre-requisites: Fundamental knowledge of solid and soil mechanics.

The theoretical part of the course will be covered by problem-based lectures.
The experimental part will be covered by hands-on element tests performed by the students in the laboratory. These experimental results will be instrumental in the calibration of advanced soil constitutive models.
The connection between the experimental and theoretical parts of the course will be facilitated by means of numerical investigations (i.e., FE analyses), including the selection and calibration of relevant constitutive models. The numerical investigations shall be documented by the students in a final report.

Laboratory equipment will be available for 60 students. Students registered for the Geotechnics Specialty in Masters will be given priority as follows: (1) 2nd year students; (2) 1st year students, (3) doctoral students taking the class for their qualifying exam; Further students will be admitted on a first-come-first-served basis.
Content
This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.

Lectures:
The lectures will cover the following contents:
- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);
- Connection principles and types for glass elements (mechanical fixing, adhesive bonding, fixed spigots);
- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);
- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);
- Typologies and design of structural systems for transparent façades;
- Requirements and functions for transparent façades.

Design exercises:
The principles and methods presented in the lectures are practiced in the students with design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.

Design project:
The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their assembly; structurally design selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.

Lecture notes
The lectures are based on lecture slides and handouts.

Literature
Recommended and supplementary literature:

Prerequisites / notice
Prior knowledge of structural analysis is necessary. Prior basic knowledge on the method of finite elements is recommended.

101-0250-00L Solving Partial Differential Equations in Parallel on GPUs
W 4 credits 3G L. Räss, S. Omlin, M. Werder

Abstract
This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

Objective
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Content
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn about the diffusion process and how to solve it;
- Understand the practical challenges of parallel and distributed computing: (multi-)GPUs, multi-core CPUs;
- Learn about software development tools: git, version control, continuous integration (CI), unit tests.

Part 2 - Developing your own parallel algorithms
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Implement efficient iterative algorithms;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPUs);
- Learn about main simulation performance limiters.

Part 3 - Final project
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

101-0659-01L Durability and Maintenance of Reinforced Concrete
W 4 credits 2V U. Angst, Z. Zhang

Abstract
We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.
After this course you will have profound understanding about:
- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:
- current engineering approaches for durability design (according to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- preventive measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies

The course is based on the book
Opportunities and limitations of concrete technology.

The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Form of teaching:
- Special handouts and reprints for particular topics will be distributed

Lecture notes
The course is based on the book

Slides of the lectures will be distributed in advance

Special handouts and reprints for particular topics will be distributed

Report:
Each student will work on a small case study and deliver a report during the semester. The report will be graded.

Excursion:
- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Prerequisites / notice
The course is based on the book

Slides of the lectures will be distributed in advance

Form of teaching:
The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

Report:
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Excursion:
We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Concrete Technology
W 2 credits 2G F. Nägele, M. Bäuml, G. Martinola, T. Wangler

Abstract
Opportunities and limitations of concrete technology. Commodities and leading edge specialties.

Objective
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.
Content

Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as
  - self compacting concrete
  - fiber reinforced concrete
  - fast setting concrete
  - fair faced concrete
  - recycled concrete
- new research in digital fabrication with concrete

Lecture notes

Slides provided for download.

Fostered competencies

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<tr>
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101-0427-01L Public Transport Design and Operations

W 6 credits 4G F. Corman, T.-H. Yan

Abstract

This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.

Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders.

The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

Content

Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes

Lecture slides are provided.

Literature

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)
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101-0492-00L Microscopic Modelling and Simulation of Traffic Operations

W 3 credits 2G M. Makridis

Abstract

The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.

Objective

The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present交通 properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microscopic simulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:

1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:

1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/ extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and present) across the semester. A mid-term and final presentation of the work will be asked from each group of students.

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Lecture notes

The lecture notes and additional handouts will be provided before the lectures. Additional literature recommendations will be provided at the lectures.

Literature

Additional literature recommendations will be provided at the lectures.

Prerequisites / notice

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Fostered competencies

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101-0527-10L Materials and Constructions

W 3 credits 2G G. Habert, M. Posani

Abstract

Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction.
Special focus on regenerative materials: earth, bio-based and reuse

The students will acquire knowledge in the following fields:

- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope:
  - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
  - Insulating materials (bio-based vs conventional)
  - Air barrier, vapour barrier and sealants
  - Interior finishing
- Assessment of materials and components behaviour and performance
- Solutions for energy retrofitting of (historical) buildings
- Aspects of sustainability and durability

### Content

**Objective**

The students will acquire knowledge in the following fields:

- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope:
  - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
  - Insulating materials (bio-based vs conventional)
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  - Interior finishing
- Assessment of materials and components behaviour and performance
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- Aspects of sustainability and durability

### Content

**Introduction**

- Sustainable cement and concrete
- Earth construction
- Visit
- Steel and bamboo
- Timber construction
- Building physic and conventional insulation
- Bio-based insulation
- Finishing
- Reuse

### Workshop on Sustainable Building Certification

**101-0587-00L**

*Does not take place this semester.*

**Number of participants limited to 25**

**Objective**

- After this course, the students are able to understand and use the different certification labels.
- They have a clear view of what the labels take into consideration and what they don’t.

**Content**

- Three buildings case study will be presented.
- Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

### Structural Design

**101-0123-00L**

**Objective**

- The students will be introduced to the main principles of graphic statics through a series of frontal lectures and discuss the relationship to analytical statics. Graphic statics is then used as an operative tool to design structures in equilibrium based on the lower bound theorem of the Theory of Plasticity. Additionally, the course will introduce contemporary methodologies and tools (parametric CAD software) for the interactive application of equilibrium modelling in the form of short workshops. The students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks.

**Content**

- Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students’ ability to integrate architectural considerations into their structural design.
The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Lecture notes Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

### Projects

#### Projects (Programme Regulations 2006)

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Working on a concrete task in Construction Engineering

Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

The project work is supervised by a professor. Students can choose from different subjects and tasks.

The project work requires normally 250 to 300 hours of work.

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Working on a concrete task in Hydraulic Engineering

Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

The project work is supervised by a professor. Students can choose from different subjects and tasks.

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<td>Project on Geotechnical Engineering [4] Only for Civil Engineering MSc, Programme Regulations 2006.</td>
<td>W</td>
<td>9 credits</td>
<td>19A</td>
<td>Supervisors</td>
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Working on a concrete task in Geotechnical Engineering

Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

The project work is supervised by a professor. Students can choose from different subjects and tasks.

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Working on a concrete task on Transport Systems

Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

The project work is supervised by a professor. Students can choose from different subjects and tasks.

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Working on a concrete task in Construction and Maintenance Management

Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

The project work is supervised by a professor. Students can choose from different subjects and tasks.
Objective

Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.

Content

The project work is supervised by a professor. Students can choose from different subjects and tasks.

101-0698-01L  Project on Materials and Mechanics

Only for Civil Engineering MSc, Programme Regulations 2006.

Objective

Working on a concrete task in Materials and Mechanics

Content

The project work is supervised by a professor. Students can choose from different subjects and tasks.

Master’s Thesis

Number  Title  Type  ECTS  Hours  Lecturers

101-0010-00L  Master’s Thesis

Only for Civil Engineering MSc, Programme Regulations 2006.

Abstract

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;

b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Objective

To work independently and to produce a scientifically structured work.

Content

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

Electives

The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

Electives ETH Zurich

Recommended Electives of Master Programme

Number  Title  Type  ECTS  Hours  Lecturers

363-1047-00L  Urban Systems and Transportation

This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

Objective

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

Content

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong microfoundations and allow for precise policy recommendations.

Lecture notes

Course slides will be made available to students prior to each class.

Literature

Course slides will be made available to students.
How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. How do we look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their design.

Content

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instabilitiy present in the contemporary city and understand how urban form evolved to its current stage.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasons, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

Lecture notes

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of recorded lectures

Literature

- Reading material will be provided throughout the semester.

Objective

Students will work to develop materials from on-site resources: earth, crushed bricks and concrete, plaster and stone. Students will learn about embodied emissions of material production and how to overcome durability issues related with low carbon materials. It's an hands-on workshop which lasts 10 days and is closed by a presentation in front of the main actors of the project: city of Paris, architects, industries.

Content

On the 27th June 2022, the team led by landscape designer Bas Smets with GRAU as urban planners and architects and Neuville-Gayet as heritage architects won the competition of the surroundings of Notre Dame Cathedral. They won with the idea to develop a material made with the raw elements from the site that can contribute to a long term discussion between the material history and future use of an underground space by the next generations. Based on the first mix design developed, this workshop aims to deepen the research on this material potential.

The workshop is articulated around central questions:

- How to design a material for eternity if it is made out rubbles of concrete, earth and stone?
- Should we design for eternity or accept decay?
- And more fundamentally, how much carbon emission is it reasonable to emit for a project that will transform the main square in front of an eight hundred years old cathedral? This raises the question of what heritage do we want to bequeath to the next generation? A Cathedral square and/or a climate and functioning ecosystem that allows them to thrive?

The workshop is based on a combination of hands-on experiments and guest lectures on the architectural intention around Notre Dame renovation, on Life Cycle Assessment and material science of building materials.

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The workshop is based on a combination of hands-on experiments and guest lectures on the architectural intention around Notre Dame renovation, on Life Cycle Assessment and material science of building materials.

The first week explores the influence of processing and material presentation on colors and textures.

The second week dives into durability questions, maintenance and transformations over decades and centuries. By the end of the workshop, the students will present by group their work to selected stakeholders involved in the project as well as key experts from architecture preservation, material and sustainability science.

Low Carbon materials explored during workshop is mainly poured earth, or earth concrete, which is a new technology well adapted to cities areas. The earth as liquid form is poured into a formwork and uncast after several hours to produce wall elements. Floors can be also done with this technology as it is currently done with concrete slab. It is a local material when excavated material from the site is used. It is nearly zero carbon as the additives used to modify its properties (water resistance, strength, fluidity) require low energy for their production (bio-additives...)) and circular as the material can be returned to nature without environmental and societal impact. We will work with earth, limestone, plaster and demolished bricks and concrete as they are the main materials available in Paris.

Prerequisites / notice

A strong motivation to hands on experiments and a deep commitment to sustainability.

101-0599-10L New Materiality for the Passage Notre Dame W 2 credits 4P G. Habert

Abstract

The workshop aims at developing low carbon and long lasting materials for the renovation of the passage Notre Dame.

Objective

The workshop is based on a combination of hands-on experiments and guest lectures on the architectural intention around Notre Dame renovation, on Life Cycle Assessment and material science of building materials.

Content

On the 27th June 2022, the team led by landscape designer Bas Smets with GRAU as urban planners and architects and Neuville-Gayet as heritage architects won the competition of the surroundings of Notre Dame Cathedral. They won with the idea to develop a material made with the raw elements from the site that can contribute to a long term discussion between the material history and future use of an underground space by the next generations. Based on the first mix design developed, this workshop aims to deepen the research on this material potential.

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Low Carbon materials explored during workshop is mainly poured earth, or earth concrete, which is a new technology well adapted to cities areas. The earth as liquid form is poured into a formwork and uncast after several hours to produce wall elements. Floors can be also done with this technology as it is currently done with concrete slab. It is a local material when excavated material from the site is used. It is nearly zero carbon as the additives used to modify its properties (water resistance, strength, fluidity) require low energy for their production (bio-additives...)) and circular as the material can be returned to nature without environmental and societal impact. We will work with earth, limestone, plaster and demolished bricks and concrete as they are the main materials available in Paris.

Prerequisites / notice

A strong motivation to hands on experiments and a deep commitment to sustainability.
### Course Units for Additional Admission Requirements

The courses below are only available to MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0710-00L</td>
<td>Digital Engineering</td>
<td>E-</td>
<td>3 credits</td>
<td>4G</td>
<td>to be announced</td>
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</tbody>
</table>

Does not take place this semester.

Remark: Will only be offered as of FS23.

#### Civil Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>W</th>
<th>Eligible for credits</th>
<th>Dr</th>
<th>Suitable for doctorate</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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</tbody>
</table>

#### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</table>

#### ECTS
- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0011-02L</td>
<td>General Chemistry (Inorganic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Content</td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibration, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform</td>
<td></td>
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</tr>
<tr>
<td>529-0011-03L</td>
<td>General Chemistry (Organic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Chen</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.</td>
<td></td>
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<tr>
<td></td>
<td>Objective</td>
<td>Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Content</td>
<td>Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topictity, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intermolecular interactions.</td>
<td></td>
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<tr>
<td></td>
<td>Lecture notes</td>
<td>Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt</td>
<td></td>
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<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
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<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td></td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td>Project Management</td>
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<td>Personal Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td></td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</tr>
<tr>
<td>529-0011-01L</td>
<td>General Chemistry (Physical Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>H. J. Wörner</td>
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<tr>
<td></td>
<td>Abstract</td>
<td>The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.</td>
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<tr>
<td></td>
<td>Objective</td>
<td>After the lecture, students will be able to,</td>
<td></td>
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<td></td>
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<td>- to calculate physical quantities and their units which are important for chemistry,</td>
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<td></td>
<td></td>
<td>- name some properties of chemically relevant particles and propose experimental methods to determine these properties,</td>
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<tr>
<td></td>
<td></td>
<td>- explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,</td>
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<td></td>
<td></td>
<td>- analyze and calculate absorption and emission spectra of single-electron atoms,</td>
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<td></td>
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<td>- to set up the Schrödinger equation for a molecular multi-particle system,</td>
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<tr>
<td></td>
<td></td>
<td>- independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems,</td>
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<tr>
<td></td>
<td></td>
<td>- model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model,</td>
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<tr>
<td></td>
<td></td>
<td>- explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom,</td>
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<td></td>
<td></td>
<td>- explain the structure of the periodic table of elements with the help of the orbital concept,</td>
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<tr>
<td></td>
<td></td>
<td>- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and</td>
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<tr>
<td></td>
<td></td>
<td>- establish term symbols for atomic ground states.</td>
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</tr>
<tr>
<td></td>
<td>Content</td>
<td>Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td>See homepage of the lecture.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td>See homepage of the lecture.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td>Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>
Acquire a starting package concerning the computational aspects of natural sciences; discuss fundamentals of computer architecture, scripting.

**Mathematical Foundations I: Analysis**

Objectives:

- Introduction to calculus, molecular biology and evolutionary principles

Content:

- Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.
- Macromolecules: Proteins
- Membranes and transport across the plasma membrane
- Universal mechanisms of inheritance, transcription and translation
- Reaction Kinetics, binding equilibria and enzymatic catalysis
- Essentials of Catabolism
- Essentials of Anabolism
- Metabolism and biogeochemical cycling of elements

Lecture notes:

- The newly conceived lecture is supported by scripts.

**Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation. Exercises:**

- Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

**Fundamentals of Biology I: From Molecules to the Cell**

- Introduction to biochemistry, molecular biology and evolutionary principles

**Introduction to Calculus in One Dimension. Building Simple Models and Analysing Them Mathematically.**

Lecture notes:

- Vieweg further reading suggestions will be indicated during the lecture

**Biochemistry of Cells**

- Geochemical perspectives on Earth and introduction to evolution
- Building blocks of life
- Essentials of Catabolism
- Essentials of Anabolism
- Metabolism and biogeochemical cycling of elements

Lecture notes:

- The lecture is supported by scripts.

Literature:

- G. B. Thomas, M. D. Weir, J. Hass: Analysis I, Lehr- und Übungsbuch, Pearson-Verlag
- R. Sperb/M. Akveld: Analysis I (vdf)
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

**Mathematical Foundations I: Analysis**

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Introduction to Computer Science**

- Linux, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

- Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

For more information about the lecture: www.csms.ethz.ch/education/Infol
The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. The students will acquire knowledge on the fundamentals of radioactive decay and radiochemistry. Furthermore, they will be familiar with the basics of inorganic chemistry of lanthanides and actinides.

**Lecture notes**

Eine kommentierte Foliensammlung ist im HCI-Shop erhältlich.

**Literature**


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### Examination Blocks

#### Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
<th>Prerequisites</th>
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<tr>
<td>529-0121-00L</td>
<td>Inorganic Chemistry I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>H. Grützmacher, P. Steinegger</td>
<td></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals as well as the lanthanides and actinides. Introduction of methods of characterization, physical-chemical properties of coordination compounds as well as principles of radiochemistry.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. The students will acquire knowledge on the fundamentals of radioactive decay and radiochemistry. Furthermore, they will be familiar with the basics of inorganic chemistry of lanthanides and actinides.</td>
<td></td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>This course consists of the following parts, which introduce the students to the chemistry of transition metals as well as lanthanides and actinides: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) Properties and characterization of coordination compounds; 9) Introduction to radiochemistry; 10) Principles of the chemistry of the lanthanides and actinides.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Eine kommentierte Foliensammlung ist im HCI-Shop erhältlich.</td>
<td></td>
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</tr>
<tr>
<td><strong>Fostered competencies</strong></td>
<td>Subject-specific Competencies: Concepts and Theories, assessed; Techniques and Technologies, assessed.</td>
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</tr>
<tr>
<td><strong>Method-specific Competencies</strong></td>
<td>Analytical Competencies, not assessed; Decision-making, not assessed; Media and Digital Technologies, not assessed; Problem-solving, assessed.</td>
<td></td>
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</tr>
<tr>
<td><strong>Social Competencies</strong></td>
<td>Communication, not assessed; Cooperation and Teamwork, not assessed; Customer Orientation, not assessed; Leadership and Responsibility, not assessed; Self-presentation and Social Influence, not assessed; Sensitivity to Diversity, not assessed; Negotiation, not assessed.</td>
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<tr>
<td><strong>Personal Competencies</strong></td>
<td>Adaptability and Flexibility, not assessed; Creative Thinking, not assessed; Critical Thinking, not assessed; Integrity and Work Ethics, not assessed; Self-awareness and Self-reflection, not assessed; Self-direction and Self-management, not assessed.</td>
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<table>
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<tr>
<td>529-0221-00L</td>
<td>Organic Chemistry I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>H. Wennenmers</td>
<td></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.</td>
<td></td>
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<tr>
<td><strong>Objective</strong></td>
<td>The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.</td>
<td></td>
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</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>The lecture slides, problem sets, and additional documents are provided online. Link: <a href="https://wennenmers.ethz.ch/education.html">https://wennenmers.ethz.ch/education.html</a></td>
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<th>Hours</th>
<th>Lecturers</th>
<th>Prerequisites</th>
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<tbody>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4</td>
<td>3V+1U</td>
<td>R. Signorell</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Introduction to Chemical Reaction Kinetics</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Will be provided</td>
<td></td>
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</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Voraussetzungen: - Mathematik I und II - Allgemeine Chemie I und II - Physikalische Chemie I</td>
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<table>
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<th>Hours</th>
<th>Lecturers</th>
<th>Prerequisites</th>
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<tr>
<td>402-0043-00L</td>
<td>Physics I</td>
<td>O</td>
<td>4</td>
<td>3V+1U</td>
<td>S. P. Quanz</td>
<td></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 245 of 2416
### Examination Block II

<table>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>O</td>
<td>3</td>
<td>2</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

**Abstract**

Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

**Objective**

Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

**Lecture notes**

Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and

Organic Chemistry for Biochemistry and Chemical Biology

The synthesis and reactivity of organic molecules plays a crucial role in chemical biology, particularly for the interrogation of biological pathways and phenomena. This course will cover advanced topics in the design and synthesis of organic molecules for applications in chemical biology and chemical engineering, with particular emphasis on the mechanistic understanding of these reactions and processes.

After the completion of this lecture, the students will have an understanding of organic chemistry commonly employed in the field of chemical biology, be able to apply these concepts to the design and synthesis of tools for probing biological pathways, and explain the underlying reaction mechanisms of selective reactions.

This is an advanced organic chemistry course. Prior knowledge of organic synthesis, reactions, and mechanisms is required. Familiarity with biochemistry and biology is recommended.

Lecture notes: Lecture notes and other material relevant for the course will be available online under https://bode.ethz.ch/education.html. Relevant research articles and review papers will be available in the course and course material.

529-0731-00L Nucleic Acids and Carbohydrates

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Literature

Mainly based on original literature, a detailed list will be distributed during the lecture

Mainly based on original literature, a detailed list will be distributed during the lecture

Mainly based on original literature, a detailed list will be distributed during the lecture

Literature

- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

529-0018-00L Organic Chemistry for Biochemistry and Chemical Biology

The synthesis and reactivity of organic molecules plays a crucial role in chemical biology, particularly for the interrogation of biological pathways and phenomena. This course will cover advanced topics in the design and synthesis of organic molecules for applications in chemical biology and chemical engineering, with particular emphasis on the mechanistic understanding of these reactions and processes.

After the completion of this lecture, the students will have an understanding of organic chemistry commonly employed in the field of chemical biology, be able to apply these concepts to the design and synthesis of tools for probing biological pathways, and explain the underlying reaction mechanisms of selective reactions.

This is an advanced organic chemistry course. Prior knowledge of organic synthesis, reactions, and mechanisms is required. Familiarity with biochemistry and biology is recommended.

Lecture notes: Lecture notes and other material relevant for the course will be available online under https://bode.ethz.ch/education.html. Relevant research articles and review papers will be available in the course and course material.

529-0124-00L BCB I: General Chemistry

Qualitative analysis (cation and anion detection), acid-base equilibrium (pH, titrations, buffers), precipitation equilibrium (gravimetric, photopotentiometry, conductivity), redox reactions (synthesis, redox titrations, galvanic elements), metal complexes (synthesis, complexometric titration)

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 247 of 2416
Objective
Qualitative analysis (simple cation and anion separation, detection of cations and anions), acid-base equilibrium (acid and base strength, pH and pKa values, titrations, buffers, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation numbers and redox behavior (synthesis, redox titrations, galvanic elements), metal complexes (synthesis of complexes, ligand exchange reactions, complexometric titration).

Content
The practical course in general chemistry is intended to introduce students to scientific work and familiarize them with simple experimental work in the laboratory. The aim is to gain initial experience with the reaction behavior of substances. In addition to a series of quantitative experiments, qualitative experiments provide knowledge about the chemical properties of substances. The individual experiments are selected in such a way that the most varied possible overview of substance classes and phenomena of chemistry is obtained.

Lecture notes
http://www.gruetzmacher.ethz.ch/education/labcourses

Literature
https://bode.ethz.ch/education/bcb-iii/bcb-iii-lab-course.html

Prerequisites / notice
Safety concept: https://chab.ethz.ch/studium/bachelor1.html

529-0016-00L

| Subject-specific Competencies | Concepts and Theories | assessed
|-------------------------------|----------------------|------------
| Techiniques and Technologies | assessed
| Method-specific Competencies | Analytical Competencies | assessed
| Decision-making | assessed
| Media and Digital Technologies | not assessed
| Problem-solving | assessed
| Social Competencies | Communication | not assessed
| Cooperation and Teamwork | not assessed
| Customer Orientation | not assessed
| Leadership and Responsibility | not assessed
| Self-presentation and Social Influence | not assessed
| Sensitivity to Diversity | not assessed
| Negotiation | not assessed
| Personal Competencies | Adaptability and Flexibility | not assessed
| Creative Thinking | not assessed
| Critical Thinking | not assessed
| Integrity and Work Ethics | not assessed
| Self-awareness and Self-reflection | not assessed
| Self-direction and Self-management | not assessed

Block Courses

Please note the ETH admission criteria for the admission of ETH students to ETH block courses on the block course registration website under "allocation".

Block Courses in the 1st half of the Semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12 credits</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective
Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, present the obtained results in a seminar.

Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Lecture notes
No course notes.

Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.
Fostered competencies

### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

### Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

### Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Media and Digital Technologies
- not assessed

### Problem-solving
- assessed

### Decision-making
- not assessed

### Project Management
- not assessed

### Social Competencies
- Communication
- not assessed
- Cooperation and Teamwork
- not assessed
- Self-presentation and Social Influence
- not assessed
- Sensitivity to Diversity
- not assessed

### Personal Competencies
- Adaptability and Flexibility
- not assessed
- Creative Thinking
- not assessed
- Critical Thinking
- not assessed
- Integrity and Work Ethics
- not assessed
- Self-awareness and Self-reflection
- not assessed
- Self-direction and Self-management
- not assessed

### Block Courses in the 2nd half of the Semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12 credits</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

- Admittance is limited and depends on the availability of hosting research labs.
- Interested students are asked to contact Prof. C. Thilgen (thilgen@org.chem.ethz.ch) before the end of the preceding semester for further details.
- In case of admittance, the actual enrolment needs to be done via the D-BIOL study administration.

**Abstract**

An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

**Objective**

Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

**Content**

An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

**Lecture notes**

No course notes.

**Literature**

No set textbooks. Literature will be indicated or provided by the supervising TAs.

**Prerequisites / notice**

Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.

### Block courses in the 1st quarter of the semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1129-00L</td>
<td>Understanding and Engineering Microbial Metabolism</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>J. Vorholt-Zambelli</td>
</tr>
</tbody>
</table>

This laboratory course has a focus on current research topics in our laboratory related to metabolic engineering, the general understanding of metabolism, and is partially focused on one carbon metabolism. Projects will be conducted in small groups.

**Objective**

The course aims at introducing technologies to investigate bacterial metabolism and key principles of metabolic engineering. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular genetic, biochemical and analytical techniques including metabolomics. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.

**Content**

The course and will include topics such as pathway elucidation & engineering and related ongoing research projects in the lab.

**Lecture notes**

None
The Mechanisms of Natural Transformation in Competent Gram-Negative Bacteria

**Number of participants limited to 5.**

*The enrolment is done by the D-BIOL study administration.*

**Abstract**

Students will carry out defined research projects related to the current research topics of the Hospenthal group. The topics will include protein expression of pilins and/or other competence proteins from Gram-negative bacteria, protein purification using affinity chromatography, crystallisation experiments and analysis of assembled pil by electron microscopy.

**Objective**

The course should enable students to understand concepts of protein expression, purification and the characterisation of biomolecular interactions. In addition, students will learn some basic principles of X-ray crystallography and electron microscopy.

**Content**

The students will be tutored in their experimental work by an experienced doctoral student. The course will also include a short lecture delivered by M. Hospenthal, providing the theoretical background for the experimental work. Throughout the course, students will receive exercises that further help to explain the theory of the practical work, as well as literature research tasks.

Participation in the following Hospenthal lab projects will be possible:

- Purification, biophysical characterisation and structure determination of pilins
- Purification, biophysical characterisation and structure determination of proteins and protein complexes involved in natural transformation.

Experimental work on this project involves:

- Cloning and mutagenesis
- Recombinant or endogenous protein production in E. coli or Legionella
- Protein purification by affinity chromatography (other chromatographic purification techniques will also be discussed)
- Protein crystallisation and crystal optimisation
- Visualisation of bacterial pil by electron microscopy (negative stain or cryo electron microscopy)
- DNA binding experiments
- Enzymatic activity measurements
- In silico structural analyses using PyMOL and Chimera

**Literature**

Any required reading of literature will be discussed at the beginning of the course.

**Prerequisites / notice**

There are no special requirements for this course.

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**Image-Based Drug Screening in Human Blood for Personalized Medicine**

**Number of participants limited to 5.**

*The enrolment is done by the D-BIOL study administration.*

**Abstract**

Image based screening allows to measure in high throughput the phenotype of millions of individual cells to external perturbations. We have recently shown that image-based screening in human blood can help to find active treatments for patients with blood cancers. In this course we will take the students through the entire workflow (to the extent that biosafety regulations allow it).

**Objective**

The students will get to know the whole workflow from experimental design, to screening and image analysis.

- Learn to design an image-based screening experiment
- Observe human blood sample handling
- Perform immunofluorescence & automated confocal microscopy
- Image analysis and result interpretation
- Result presentation

**Literature**

- Relevant study: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30208-9/fulltext
- Editorial commentary: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30213-2/fulltext

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**Block courses in the 2nd quarter of the semester**

**13.10.2022 - 4.11.2022**

**Number**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0345-00L</td>
<td>Mechanisms of Bacterial Pathogenesis</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>W.-D. Hardt, B. Nguyen</td>
</tr>
<tr>
<td>551-0421-00L</td>
<td>Biology and Ecology of Fungi in Forests</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>S. Prospero, I. L. Brunner, M. Peter Baltensweiler</td>
</tr>
</tbody>
</table>

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**Data: 01.11.2022 12:41 Autumn Semester 2022 Page 250 of 2416**
<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>W</th>
<th>ECTS</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0351-00L</td>
<td>Membrane Biology</td>
<td>W</td>
<td>6</td>
<td>V. Korkhov, U. Kutay, S. C. Zeeman</td>
</tr>
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<td></td>
<td>The enrolment is done by the D-BIOL study administration.</td>
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<tr>
<td></td>
<td>The course will introduce the students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course.</td>
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<tr>
<td></td>
<td>Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field.</td>
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<tr>
<td>Lecture notes</td>
<td>No script</td>
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<tr>
<td>Literature</td>
<td>The recommended literature, including reviews and primary research articles, will be provided during the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course will be taught in English. All general lectures will be held at ETH Hoenggerberg. Students will be divided into small groups to carry out experiments at ETH or at the Paul Scherrer Institute. Travel to the Paul Scherrer Institute will be by public transportation.</td>
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<tr>
<td>551-1201-00L</td>
<td>Computational Methods in Genome and Sequence Analysis</td>
<td>W</td>
<td>6</td>
<td>A. Wutz</td>
</tr>
<tr>
<td></td>
<td>The enrolment is done by the D-BIOL study administration.</td>
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<td></td>
<td>This course aims to provide students with a comprehensive overview of computational methods for sequence analysis and assist with developing skills for application of computational approaches by experimental scientists in the life sciences.</td>
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<tr>
<td></td>
<td>Methods for analyzing animal genomes are increasingly becoming important for applications in human health and biotechnology. This course will introduce students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course.</td>
<td></td>
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<tr>
<td></td>
<td>Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field.</td>
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<tr>
<td>Lecture notes</td>
<td>No script</td>
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<tr>
<td>Literature</td>
<td>The course will be taught in English. All general lectures will be held at ETH Hoenggerberg. Students will be divided into small groups to carry out experiments at ETH or at the Paul Scherrer Institute. Travel to the Paul Scherrer Institute will be by public transportation.</td>
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<td>Prerequisites / notice</td>
<td>The course will be taught in English. All general lectures will be held at ETH Hoenggerberg. Students will be divided into small groups to carry out experiments at ETH or at the Paul Scherrer Institute. Travel to the Paul Scherrer Institute will be by public transportation.</td>
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<tr>
<td>551-1143-00L</td>
<td>Analysis of Human T and B Cell Responses to Infectious Agents</td>
<td>W</td>
<td>6</td>
<td>F. Sallusto, R. Geiger, D. Latorre</td>
</tr>
<tr>
<td></td>
<td>The enrolment is done by the D-BIOL study administration.</td>
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<tr>
<td></td>
<td>Students actively participate in ongoing research projects on the analysis of human T and B cell responses to pathogens and vaccines. They will be tutored in small groups by doctoral students and postdocs. In a lecture series, the theoretical background for the projects will be provided and the students will have the opportunity to present their projects and discuss recent publications.</td>
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<tr>
<td>Lecture notes</td>
<td>No script</td>
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<tr>
<td>Literature</td>
<td>Descriptions of the possible projects including individual reading suggestions will be handed out beforehand.</td>
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</table>

 נכון
### 7P - Analytical Competencies

During the block course in the fall semester, we will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The class with its very dense program consists of the practical course itself and an integrated series of seminar/lecture sessions.

**Objective**

All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

**Content**

The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel, teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

**Lecture notes**

A script will be distributed to the participants on the first day of the course.

**Literature**

General literature to "Directed Evolution" and chorismate mutases, e.g.:


Further literature will be indicated in the distributed script.

**Prerequisites / notice**

This laboratory course will involve experiments that require a tight schedule and, particularly in the second half, very long (!) working days. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

**Fostered competencies**

Subject-specific Competencies: Concepts and Theories assessed

Method-specific Competencies: Analytical Competencies assessed

Social Competencies: Communication assessed

Personal Competencies: Adaptable and flexible assessed

### 6 credits

**Experimental Food Microbiology for Biologists**

**Number of participants limited to 12**

**Prerequisites:** It is recommended to attend the course Lebensmittel-Mikrobiologie (752-4005-00L) as a preparation. The course can only be booked via the Biology Student secretariat.

**Abstract**

Teaching of basic experimental knowledge for detection and identification of microorganisms in food. Practical experiments were accompanied by theoretical introductions. Students become acquainted with classical and state-of-the-art molecular techniques for the rapid detection of foodborne pathogens and experiments in dependence on current research topics of the Laboratory of Food Microbiology.

**Objective**

Introduction of methods and techniques of food microbiology

**Content**

Teaching of basic experimental knowledge for detection and identification of foodborne pathogens by applying state-of-the-art techniques as well as modern molecular techniques for the rapid identification of relevant foodborne pathogens.

**Lecture notes**

Handouts were provided at the start of the course

**Literature**

- Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- Süssmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

**Prerequisites / notice**

During the course we will work with the food-borne pathogen Listeria monocytogenes. Listeria monocytogenes represents a particular threat to pregnant women. Due to biosafety reasons participation is not allowed in case of pregnancy.

**Fostered competencies**

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Decision-making assessed

Communication assessed

Cooperation and Teamwork assessed

Adaptability and Flexibility assessed

Integrity and Work Ethics assessed

Self-awareness and Self-reflection assessed
The course is divided between lectures and practical work in the lab. The lectures will introduce the general topic of amyloids and in particular none.

Introduction to the diversity of current RNA-research at all levels from structural biology to systems biology using mainly model systems like 7P. Documentation and recommended literature will be provided at the beginning and during the course. Lecturers will be provided for each of the projects at the beginning of the course.

### Biology of Bryophytes and Ferns

**Number of participants limited to 16.**

**Abstract**
Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes; field trip.

**Objective**
Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes.

**Content**
Ferns: basic knowledge on the life cycle, morphology, evolution and ecology of ferns; identification of Swiss fern species; field trips.

**Lecture notes**
A script will be distributed to the participants on the first day of the course.

**Literature**

### RNA-Biology

**Number of participants limited to 17.**

**Abstract**
Introduction to the diversity of current RNA-research at all levels from structural biology to systems biology using mainly model systems like S. cerevisiae (yeast), mammalian cells.

**Objective**
The students will obtain an overview about the diversity of current RNA-research. They will learn to design experiments and use techniques necessary to analyze different aspects of RNA biology. Through lectures and literature seminars, they will learn about the burning questions of RNA research and discuss approaches to address these questions experimentally. In practical lab projects the students will work in one of the participating laboratories. Finally, they will learn how to present and discuss their data in an appropriate manner. Student assessment is a graded semester performance based on individual performance in the laboratory, the written exam and the poster presentation.

**Literature**
Documentation and recommended literature will be provided at the beginning and during the course.

**Prerequisites / notice**
The course will be taught in English.

### In Vivo Cryo-EM Analysis of Dynein Motor Proteins

**Number of participants limited to 5.**

**Abstract**
Motor proteins convert chemical energy into mechanical motion. In this block course, we study dynein motor proteins in cilia. Dynein causes conformational change upon ATP hydrolysis and finally generate ciliary bending motion. Participants will analyze cryo-EM data of cilia and visualize in vivo 3D structure of dynein to learn how motor proteins function in the cell.

**Objective**
The goal of this course is to become familiar with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies on motor proteins. The main focus is 3D image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.
### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0230-00L</td>
<td>Medicinal Chemistry I</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>J. Hall</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.</td>
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<tr>
<td>Content</td>
<td>Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions</td>
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<td>Lecture notes</td>
<td>Will be provided in parts before each individual lecture.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Requirements: Knowledge of physical and organic chemistry, biochemistry and biology. Attendance of Medicinal Chemistry II in the spring semester.</td>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
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<tr>
<td>Abstract</td>
<td>Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Objective</td>
<td>This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Content</td>
<td>Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Lecture notes</td>
<td>Updated handouts will be provided during the class.</td>
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<tr>
<td>Literature</td>
<td>Current literature references will be provided during the lectures.</td>
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</table>
| Prerequisites / notice| English  
The lecture “Grundlagen der Biologie II: Mikrobiologie” is the basis for this advanced lecture. |

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<tr>
<th>Number</th>
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<tr>
<td>529-0041-00L</td>
<td>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano</td>
</tr>
<tr>
<td>Abstract</td>
<td>Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.</td>
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<tr>
<td>Objective</td>
<td>Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.</td>
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<tr>
<td>Content</td>
<td>Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).</td>
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<td>Lecture notes</td>
<td>Lecture notes will be made available online.</td>
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<tr>
<td>Literature</td>
<td>Information about relevant literature will be available in the lecture &amp; in the lecture notes.</td>
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</table>
| Prerequisites / notice| Exercises are an integral part of the lecture.  
Prerequisites:  
529-0051-00 “Analytische Chemie I (3. Semester)”  
529-0058-00 “Analytische Chemie II (4. Semester)” (or equivalent) |

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Content

Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. Their function is essential for intracellular transport, muscle contraction and other cellular motility as well as cell division. Motor proteins have been major targets of biophysical studies. There exist questions from atomic to tissue levels – how ATP hydrolysis causes conformational change of motor proteins; how their motion is regulated by calcium, phosphorylation and other factors; how motions of multiple motor proteins are coordinated to generate cellular motility. Structural biology has been playing central roles to answer these questions. X-ray crystallography and single particle cryo-EM address structural analysis at atomic resolution and try to reveal molecular mechanism of conformational change. Cryo-electron tomography analyze localization and 3D structure of motor proteins in the cell to explain how motions of molecular motors happen in the context of cellular environment and are integrated into cellular motion. In this course, we study dyneins in cilia. Cilia are force-generating organelles, made by nine microtubules and thousands of dyneins. Dynein hydrolyzes ATP and undergoes conformational change, generating linear motion with respect to the microtubule. As a whole system, cilia integrate motions of these dyneins and orchestrate beating motion. To explain ciliary motion at molecular level, we need to know dynein conformational change in the cellular context. Cryo-electron tomography is recently developed technique to study molecular structures in vivo and therefore a suitable method to study dynein in cilia. Recently spatial resolution of these cryo-EM techniques was dramatically improved, driven by development of new types of detectors and electron optics. The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dyneins, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH. 

**Microbiology (Part I)**

Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation.

Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

The lecture “Grundlagen der Biologie II: Mikrobiologie” is the basis for this advanced lecture.


**Objective**

Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

**Content**

Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions.

**Lecture notes**

Will be provided in parts before each individual lecture.

**Literature**


**Prerequisites / notice**

Requirements: Knowledge of physical and organic chemistry, biochemistry and biology. Attendance of Medicinal Chemistry II in the spring semester.
Inorganic Chemistry III: Organometallic Chemistry and Homogeneous Catalysis

529-0132-00L

Abstract
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbonylation, C-C bond-forming and related reactions.

Objective
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

Content
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbonylation, C-C bond-forming and related reactions.

Cellular Biochemistry (Part I)

551-0319-00L

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.bioc.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Biochemistry – Chemical Biology Bachelor - Key for Type

W Eligible for credits
E- Recommended, not eligible for credits
Z Courses outside the curriculum

Dr Suitable for doctorate
O Compulsory
W+ Eligible for credits and recommended
<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Complementary Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>376-1791-00L</td>
<td>Introductory Course in Neuroscience I (University of</td>
<td>Z Dr</td>
<td>2 credits</td>
<td>2V</td>
<td>University lecturers</td>
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<td>Zurich)</td>
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<td><strong>No enrolment to this course at ETH Zurich. Book the</strong></td>
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<td><strong>corresponding module directly at UZH as an incoming</strong></td>
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<td><strong>Mind the enrolment deadlines at UZH:</strong></td>
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<td><strong><a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline">https://www.uzh.ch/cmsssl/en/studies/application/deadline</a></strong></td>
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<td><strong>The course gives an introduction to human and</strong></td>
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<td><strong>comparative neuroanatomy, molecular, cellular and</strong></td>
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<td><strong>systems neuroscience.</strong></td>
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<td><strong>The course gives an introduction to the development</strong></td>
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<td><strong>and anatomical structure of nervous systems.</strong></td>
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<td><strong>Furthermore, it discusses the basics of</strong></td>
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<td><strong>cellular neurophysiology and neuropharmacology.</strong></td>
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<td><strong>Finally, the nervous system is described on a</strong></td>
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<td><strong>system level.</strong></td>
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<td>1) Human Neuroanatomy I &amp;II</td>
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<td>2) Comparative Neuroanatomy</td>
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<td>3) Building a central nervous system I,II</td>
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<td>4) Synapses I,II</td>
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<td>6) Excitability</td>
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<td>7) Circuits underlying Emotion</td>
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<td>8) Visual System</td>
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<td>9) Auditory &amp; Vestibular System</td>
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<td>10) Somatosensory and Motor Systems</td>
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<td>11) Learning in artificial and biological neural networks</td>
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<td>For doctoral students of the Neuroscience Center Zurich (ZNZ).</td>
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<tr>
<td>151-0927-00L</td>
<td>Rate-Controlled Separations in Fine Chemistry</td>
<td>Z Dr</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>M. Mazzotti, V. Becattini</td>
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<td><strong>Abstract</strong></td>
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<td>The students are supposed to obtain detailed insight</td>
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<td>into the fundamentals of separation processes that are</td>
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<td>frequently applied in modern life science processes</td>
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<td>in particular, fine chemistry and biotechnology, and</td>
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<td>in energy-related applications.</td>
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<td>in particular, fine chemistry and biotechnology.</td>
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<td><strong>Content</strong></td>
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<td>The class covers separation techniques that are central</td>
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<td>in the purification and downstream processing of</td>
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<td>chemicals and bio-pharmaceuticals. Examples from both</td>
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<td>areas illustrate the utility of the methods: 1)</td>
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<td>Adsorption and chromatography; 2) Membrane processes;</td>
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<td>3) Crystallization and precipitation.</td>
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<td><strong>Lecture notes</strong></td>
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<td><strong>Literature</strong></td>
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<td>Recommendations for text books will be covered in the</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Requirements (recommended, not mandatory): Thermal</td>
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<td>separation Processes I (151-0926-00) and Modelling and</td>
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<td>mathematical methods in process and chemical</td>
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<td>Media and Digital Technologies</td>
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<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
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<td>The students acquire advanced practical skills in</td>
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<td>and then proceeds to parameter estimation, tests,</td>
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<td>regression for binary response variables, binomial</td>
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<td><strong>Lecture notes</strong></td>
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Prerequisites / notice

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

Literature

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Abstract

The course consists of a series of research seminars on Structural Biology, Biochemistry and Biophysics, given by both scientists of the National Center of Competence in Research (NCCR) in Structural Biology and external speakers. Information on the individual seminars is provided on the following websites:
http://www.structuralbiology.uzh.ch/educ002.asp
http://www.biol.ethz.ch/dbiol-cal/index

Objective

The goal of this course is to provide doctoral and postdoctoral students with a broad overview on the most recent developments in biochemistry, structural biology and biophysics.

551-1619-00L Structural Biology Z Dr 1 credit 1K R. Glockshuber, F. Altain, N. Ban, K. Locher, M. Pilhofer, E. Weber-Ban, K. Wüthrich
Does not take place this semester.

Abstract

The course consists of a series of research seminars on Structural Biology, Biochemistry and Biophysics, given by both scientists of the National Center of Competence in Research (NCCR) in Structural Biology and external speakers. Information on the individual seminars is provided on the following websites:
http://www.structuralbiology.uzh.ch/educ002.asp
http://www.biol.ethz.ch/dbiol-cal/index

Objective

The goal of this course is to provide doctoral and postdoctoral students with a broad overview on the most recent developments in biochemistry, structural biology and biophysics.

851-0180-00L Research Ethics Z Dr 2 credits 2G G. Achermann, P. Emch

Number of participants limited to 40

Abstract

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective

Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people's arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning
II. Ethics - the basics
  1. What ethics is not... 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
  1. What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in "Research Ethics"

3. Decision making: How to solve a moral dilemma
  1.1 How (not) to approach ethical issues 2.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a "right" answer?

II. Research Ethics - Internal responsibilities
  1. Integrity in research and research misconduct
     1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
  2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
  3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics - External responsibilities
  1. Research involving human subjects
     1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
  2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
  3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...).

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
  Decision-making assessed
  Problem-solving assessed
Social Competencies
Communication assessed
Personal Competencies
Creative Thinking assessed
  Critical Thinking assessed
  Integrity and Work Ethics assessed
  Self-awareness and Self-reflection assessed

376-1581-00L  Cancer: Fundamentals, Origin and Therapy  Z  2 credits  2G  H. Nägeli

Abstract

Objective
Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or chemical exposure and resulting in a tumor. They are able to list important cancer-inducing agents and explain the respective mechanism of action. They have knowledge of significant risk factors for cancer diseases. They are confronted with the basics of toxicology and they can explain the principle of the most common therapeutic strategies.

Content
The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process. Classes of chemical compounds that induce cancer are discussed as well as the reactive metabolites that may be built from. Covalent binding to DNA is discussed and different types of mutations resulting therof. A selection of proto-oncogenes and tumor suppressor genes is presented. Their function will be discussed as well as the changes which are found in these genes in tumor cells, starting from single nucleotide exchanges up to large deletions.

The reason for genetic predisposition to cancer will be discussed as well as cancer relevant aspects of cell cycle regulation. The role of tumor microenvironments and phenomena like angiogenesis and metastasis are presented as well as the mechanisms that protect the genome from mutagenic damage. Further subjects address old and new strategies of cancer treatment. Personalised cancer treatment.

Lecture notes
Handouts with reproductions of all presented transparencies will be distributed.

Literature
  
  additional information is given during the lecture
Prerequisites / notice
Fostered competencies

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Personal Competencies

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Abstract

About 5 talks on applied statistics.

Objective

See how statistical methods are applied in practice.

Content

There will be about 5 talks on how statistical methods are applied in practice.

Prerequisites / notice

This is no lecture. There is no exam and no credit points will be awarded. The current program can be found on the web: http://stat.ethz.ch/events/zukost
Course language is English or German and may depend on the speaker.

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551-1109-00L  Seminars in Microbiology  Z Dr  0 credits  2K  S. Sunagawa, W.-D. Hardt, M. Künzler, J. Piel, J. Vorholt-Zambelli

Abstract

Seminars by invited speakers covering selected microbiology themes.

Objective

Discussion of selected microbiology themes presented by invited speakers.

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401-0620-00L  Statistical Consulting  Z Dr  0 credits  0.1K  M. Kalisch, L. Meier

Abstract

The Statistical Consulting service is open for all members of ETH, including students, and partly also to other persons.

Objective

Advice for analyzing data by statistical methods.

Content

Students and researchers can get advice for analyzing scientific data, often for a thesis. We highly recommend to contact the consulting service when planning a project, not only towards the end of analyzing the resulting data!

Prerequisites / notice

This is not a course, but a consulting service. There are no exams nor credits.

Contact: beratung@stat.math.ethz.ch . Tel. 044 632 2223. See also http://stat.ethz.ch/consulting

Requirements: Knowledge of the basic concepts of statistics is desirable.

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551-0512-00L  Current Topics in Molecular and Cellular Neurobiology  Z Dr  2 credits  1S  U. Suter

Abstract

The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

Objective

The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

Content

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

Lecture notes

Presentations will be made available after the seminar.

Prerequisites / notice

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

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701-1401-00L  Ecology and Evolution: Interaction Seminar  Z  2 credits  2S  A. Hall

Abstract

Interaction seminar. Student-mediated presentations, guest lectures and discussions on current research topics, in ecology, evolutionary and population biology.

Objective

Getting familiar with scientific arguments and discussions. Overview of current research topics. Making contacts with fellow students in other groups.

Content

Scientific talks and discussions on changing subjects.

Lecture notes

None
Precise and transparent presentation of research findings in relation to the current literature, critical discussion of experimental data and technology-based interactions between the participating research groups.

Presentation and discussion of current research projects carried out by various immunology-oriented research groups in Zurich.

This monthly meeting is a platform for Zurich-based immunology research groups to present and discuss their ongoing research projects.

Participants will be able to:

- Review issues of sustainability in the context of plant science research and literature on sustainable agriculture and the food system.
- Analyze and interact on several case studies in agro-ecology and the food system.
- Use SDGs in your case study as a target and assessment system for sustainability in agriculture and in the food system.
- Future society has to feed nine billion people, therefore agriculture but also food, waste and resource management has to go hand in hand in the use of less resources. We will discuss current plant science research in the context of sustainability.
- Focus of the seminar will be on:
  1. Research on agro-ecological systems and farming system research. Can we transform the impact of our agricultural practices below the planetary boundaries? Where does current research indicate on directions for a transformation of current practice?
  2. The Sustainable Development Goals that should guide the current contributions of plant sciences: What research and innovation are necessary to contribute to the SDGs?
  3. Building sustainable food systems: How could local food systems be build and scaled up? In this topic, our focus is on giving insight in policy strategies and local sustainability efforts to give the group of participants an opportunity to understand sustainability in the local societal context.

The course will be organized with two workshops (half days, 14:00 - 18:00) and an intensive, well-structured self-study/ group work phase in between the workshops.

Online learning material is for example provided on:

- Nitrogen supply in tropical low input conservation agriculture
- Nitrous oxide emissions from agriculture
- Role of vascular plants in methane emissions from soil
- Mycorrhizal symbioses for soil nutrient management in agro-ecosystems

Case Studies:

- Mycorrhizal symbioses for soil nutrient management in agro-ecosystems
- Role of vascular plants in methane emissions from soil
- Nitrous oxide emissions from agriculture
- Nitrogen supply in tropical low input conservation agriculture
- Mycorrhizal symbioses for soil nutrient management in agro-ecosystems

For information, location and details: https://pe.ethz.ch/education/zis.html


Access to the learning platform: https://lms.uzh.ch/auth/RepositoryEntry/3604873218/CourseNode/83441794245107 (use your AAI login)

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Problem-solving

Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence

Social Competencies
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Personal Competencies

551-1615-00L  NMR Methods for Studies of Biological Macromolecules
Prerequisites: Basic knowledge in biological NMR spectroscopy.

Abstract
Seminar series on technical aspects of high resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.

Objective
Introduction and discussion of advanced methods for recording and analysis of NMR data with biological macromolecules.

Content
Seminar series on technical aspects of high-resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.

551-1713-00L  Current Topics in Molecular Health Sciences

Abstract
This course is a seminar series on current research topics within the Institute of Molecular Health Sciences.

Objective
The course introduces the participants to recent developments in the fields of molecular health sciences.

Prerequisites / notice
Approval of the responsible lecturer necessary for participation.

402-0368-07L  Lecture Series: Space Research and Exploration

Abstract
Lecture Series about topics of space research and exploration consisting of individual talks given by different leading experts from industry and academia.

Objective
Attending students will
- experience the interdisciplinarity of space research and exploration spanning physics, engineering, geosciences, biology and more
- get familiar with the Swiss space research and industry sector
- improve their report writing skills by reflecting on one of the talks
- enhance their communication skills by broadening their research horizon
- have the opportunity for direct learning by posing questions to experts

Content
The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay between the scientifically desirable and the technologically possible. The ‘Lecture Series: Space Research and Exploration’ aims to shed light on key questions engaged by leading scientists and engineers today. It consists of weekly lecture, given by different speakers with vast experience in their respective field (e.g., Human Spaceflight, System Engineering of Spacecraft, Space Life Sciences, Space-based astrophysics). Subsequent to the talk, the student will have the opportunity to deepen their understanding by asking questions to the presenter in a moderated Q&A.

Confirmed list of speakers include:
Adrian Glauser (ETH Zürich)
Andrea Fortier (University of Bern)
Andreas Schrader (Oerlikon Additive Manufacturing)
Anna Kubik (ETH Zürich)
Claude Nicoller (EPFL, ESA Astronaut)
Deborah Müller (Space Exchange Switzerland)
Florian Kehl (UZH, HSLU, NASA-JPL)
Hendrik Kolvenbach (ETH Zürich)
Louise Harra (ETH Zürich, PMOD/WRC)
Maximilian Kirchhoff (Beyond Gravity)
Sascha P. Quanz (ETH Zürich)
Didier Queloz (ETH Zürich)
Thomas Reiter (ESA Astronaut)
Jennifer Wadsworth (UZH)

Biology (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
</tbody>
</table>

Key for Hours

| V  | lecture                          |
| G  | lecture with exercise            |
| U  | exercise                         |
| S  | seminar                          |
| K  | colloquium                       |
| P  | practical/laboratory course      |
| A  | independent project              |
| D  | diploma thesis                   |
| R  | revision course / private study  |

ECTS  European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Biology Bachelor

#### Bachelor Studies (Programme Regulations 2020)

#### First Year Courses

#### First Year Examinations

#### First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0125-00L</td>
<td>Fundamentals of Biology I: From Molecules to the Biochemistry of Cells</td>
<td>O</td>
<td>6</td>
<td>5G</td>
<td>J. Vorholt-Zambelli, N. Ban, R. Glockshuber, K. Locher, J. Piel</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

**Objective**
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

**Literature**
The newly conceived lecture is supported by scripts.


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1001-01L</td>
<td>General Chemistry (for Biol./Pharm.Sc.)</td>
<td>O</td>
<td>4</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.

**Objective**
The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.

**Literature**

Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005 (englisch)

**Fostered competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

**529-1011-00L**

**Abstract**
Fundamentals of Organic Chemistry: molecular structure. Bonding and functional groups; nomenclature; resonance and aromaticity; stereochemistry; conformation; bond strength; organic acids and bases; basic reaction thermodynamics and kinetics; reactive intermediates: carbanions, carbocation ions and radicals.

**Objective**
Understanding the basic concepts and definitions of organic chemistry. Knowledge of the functional groups and classes of compounds that are important in biological systems. Foundations for the understanding of the relationship between structure and reactivity.

**Content**
Lecture notes
Printed lecture notes are available. Exercises, answer keys and other handouts can be downloaded from the Moodle course "Organic Chemistry I" of the current semester (https://moodle-app2.let.ethz.ch).

Literature

Prerequisites / notice
The course consists of lectures (36 hours) and problem-solving lessons (20 hours, groups of ca. 25 people). In addition, online exercises are available in the e-learning environment Moodle (Course OC I).

Fostered competencies

Lecture notes

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0073-00L</td>
<td>Physics I</td>
<td>O</td>
<td>3</td>
<td>2V+2U</td>
<td>T. M. Ihn</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics and elements of quantum mechanics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Students know and understand the basic ideas of the scientific description of nature. They understand the fundamental concepts and laws of mechanics and they are able to apply them in practical problems. They know the concepts of quantization and quantum numbers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>1. Description of Motion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. The laws of Newton</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Work and energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Collision problems</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>5. Wave properties of particles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. The atomic structure of matter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>T. Ihn: Physics for Students in Biology and Pharmaceutical Sciences (unpublished lecture notes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>The lecture contains elements of:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories assessed</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Method-specific Competencies: Analytical Competencies assessed</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Social Competencies: Communication not assessed, Sensitivity to Diversity not assessed</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal Competencies: Creative Thinking not assessed, Critical Thinking not assessed, Integrity and Work Ethics not assessed, Self-awareness and Self-reflection not assessed, Self-direction and Self-management not assessed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 401-0291-00L | Mathematics I   | O    | 6    | 4V+2U | E. W. Farkas |
| Abstract     | Mathematics I/II is an introduction to one- and multidimensional calculus and linear algebra emphasizing on applications. |
| Objective    | Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences. Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems. |
## Eindimensionale diskrete Entwicklungen ##
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsraten
- Folgen und Grenzwerte

## Funktionen in einer Variablen ##
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

## Differentialrechnung (I) ##
- Veränderungsrate/-geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

## Integralrechnung (I) ##
- Stammfunktionen
- Integrationstechniken

## Gewöhnliche Differentialgleichungen (I) ##
- Qualitative Beschreibung an Beispielen: Beschränkt, Logistisch, Gompertz
- Stationäre Lösungen
- Lineare DGL 1. Ordnung
- Trennung der Variablen

## Lineare Algebra ##
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

---

**Lecture notes**

In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem **Vademecum** zusammen.

Dabei gilt:

* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

**Literature**

Siehe auch Lernmaterial > Literatur

**L. Papula**
Mathematik für Ingenieure und Naturwissenschaftler, 2 Bände; Springer Verlag Vieweg.
Via ETHZ-Bibliothek:

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände:
Einführung in die Analysis, Einführung in die Lineare Algebra;
Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF
auch als [pdf](https://people.math.ethz.ch/~blatter/linalg.pdf)

---

## Übungen und Prüfungen ##

Die Übungsaufgaben (inkl. Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltungen.
Es wird erwartet, dass Sie mindestens 75 % der wöchentlichen Serien bearbeiten und zur Korrektur einreichen.
Der Prüfungsstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

### First Year Laboratory Courses ###

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-1001-00L</td>
<td>Laboratory Course General Chemistry (for Biology and Pharmacy)</td>
<td>O</td>
<td>6 credits</td>
<td>8P</td>
<td>S. Gruber, J. Hall</td>
</tr>
</tbody>
</table>

**Information about the practical course will be given on the first day.**

Register in myStudies as early as possible, because the fire protection courses take place separately before the internship starts.

**Abstract**

Introduction to the practical work in a chemistry laboratory. The most important manipulations and techniques are treated, as well as the most fundamental chemical reaction types.
Objective
- Knowledge of the basic chemical laboratory methods
- Basic knowledge of the scientific approach in experimenting
- Observation and interpretation of chemical processes
- Keeping of a reliable laboratory journal

Content
- Simple chemical working techniques/methods
- Separation techniques
- Physical measurements: mass, volume, pH
- Ionic solids (salts)
- Acid/base chemistry, buffers
- Redox reactions
- Metal complexes
- Titration methods and quantitative spectrometry
- Introduction to qualitative analysis

Lecture notes
Course manual in German (is handed out to the students at the begin of the lessons)
Language: German, English upon request

Literature
Wiley

Prerequisites / notice
This practical course causes costs for materials and chemicals. The costs are charged to the students at the end of semester.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Second Year Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
The lecture conveys the fundamental concepts underlying multicellularity with an emphasis on the molecular basis of multicellular biological systems and their functional integration into coherent wholes. The structural and functional specialization in multicellular organisms will be discussed by highlighting common and specific functions in fungi, plants, and animals (including humans).

Objective
1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity.
2. Students can explain how the internal and external structures of fungi, plants and animals function to support survival, growth, behavior, and reproduction.
3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development).
4. Students can describe how a single cell develops from one cell into many, each with different specialized functions.

Content
The lecture introduces the structural and functional specialization in fungi, plants and animals, including humans. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi, plants, animals and humans have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, human anatomy and physiology, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.

Literature
Campbell “Biology”, 11th Edition

Prerequisites / notice
Some lecture are held in English.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1005-00L</td>
<td>Bioanalytics</td>
<td>O</td>
<td>4</td>
<td>4G</td>
<td>P. Picotti, F. Allain, V. Korkhov, M. Pilhofer, R. Schlapbach, K. Weis, K. Wüthrich, further lecturers</td>
</tr>
</tbody>
</table>

Abstract
The course will introduce students to a selected set of laboratory techniques that are foundational to modern biological research.

Objective
For each of the techniques covered in the course, the students will be able to explain:
a) the physical, chemical and biological principles underlying the technique,
b) the requirements for the sample,
c) the type of raw data collected by the technique,
d) the assumptions and auxiliary information used in the interpretation of the data and

Content
The course will be based on a combination of lectures, self-study elements and exercises.

Lecture notes
The course is supported by a Moodle page that gives access to all supporting materials necessary for the course.
Founders of Computer Science  

**Abstract**  
Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, introduction to programming, introduction matrices, managing data with lists and tables and with relational databases, universal methods for algorithm design.

**Objective**  
The students learn to:
- understand the role of computer science in science,
- to control computer and automate processes of problem solving by programming,
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

**Content**  
1. The role of computer science in science  
2. Introduction to Programming with Python  
3. Modeling and simulations  
4. Data management with lists and tables  
5. Data management with a relational database  
6. Introduction to Matrices

**Lecture notes**  
All materials for the lecture are available at www.gdi.ethz.ch

**Literature**  

**Prerequisites / notice**  
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

252-0852-00L  
Foundations of Computer Science

2V+2U  
L. E. Fässler, M. Dahinden

4 credits

401-0643-13L  
Statistics II

O  
J. Dambon

3 credits

2V+1U

529-0015-00L  
Physical Chemistry

O  
G. Jeschke, D. Klose

3 credits

2V+1U

Abstract  
Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptuelle Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

Objective  

Content  
chemical potential, prediction of the direction of processes, phase equilibria, phase rule, phase diagrams of pure substances, colligative properties, osmosis, dialysis, surface tension, intermolecular interactions, hydrophobic effect, hydrophilic effect and denaturation, amphiphiles, basics of self-association, micelles, packing parameter, double layers, vesicles, membranes, elementary reactions, parallel reactions, consecutive reactions, Eyring theory, enzyme kinetics, diffusion, heat conduction, active transport

Lecture notes  
A lecture script is provided


**Literature**

In addition to the lecture script, the following two books can be used to gain deeper understanding:


**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td></td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Analytical Competencies</td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
<td></td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
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</tr>
<tr>
<td>Problem-solving</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td></td>
</tr>
</tbody>
</table>

**Social Competencies**

<table>
<thead>
<tr>
<th>Communication</th>
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</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Not assessed</td>
</tr>
</tbody>
</table>

**Personal Competencies**

| Adaptability and Flexibility | Not assessed |
|==============================|-------------|
| Creative Thinking            |             |
| Critical Thinking            |             |
| Integrity and Work Ethics    |             |
| Self-awareness and Self-reflection | Not assessed |
| Self-direction and Self-management | Not assessed |

---

**Practical Course Organic Chemistry (for Students of Biology and Pharmaceutical Sciences)**

**Abstract**

Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography)

Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses).

**Objective**

Learn the basic techniques for the preparation and purification of organic compounds.

Learn to take accurate notes of the experiments and to write reports.

Deepen the understanding of reaction mechanisms.

**Content**

Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography).

Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses) from the following classes of reactions: 1. nucleophilic substitution at C(sp3), 2. elimination or electrophilic addition to C=C, 3. electrophilic aromatic substitution, 4. oxidation, 5. reduction, 6. Grignard reaction, 7. synthesis of a carboxylic acid derivative, 8. Aldol-, Claisen-, Mannich-, Michael reaction or Robinson annulation.

Introduction to database searches (Reaxys, SciFinder).

**Literature**

1) P. Wörfel, M. Bitzer, U. Claus, H. Felber, M. Hübel, B. Vollenweider, *Laborpraxis (Bd. 1: Einführung, allgemeine Methoden; Bd. 2: Messmethoden; Bd. 3: Trennungsmethoden; Bd. 4: Analytische Methoden);* Birkhäuser Verlag; Basel; 1990.


**Prerequisites / notice**

The basic reactions of Organic Chemistry and their mechanisms should be known and the corresponding exam have been passed (cf. course 529-1012-00L Organic Chemistry II for Students of Biology, Pharmaceutical Sciences, and Health Sci. and Tech.).

As a prerequisite, all participants need to pass the "Safety Test HCI Chemie_V2 English" (see https://moodle-app2.let.ethz.ch). A printout of the certificate generated by the system needs to be presented to the teaching assistants prior to starting lab work.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed</th>
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<tbody>
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<td>Techniques and Technologies</td>
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<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Assessed</th>
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</thead>
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<tr>
<td>Analytical Competencies</td>
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</tr>
<tr>
<td>Media and Digital Technologies</td>
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<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Assessed</th>
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<tbody>
<tr>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Assessed</th>
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<tbody>
<tr>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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</tr>
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<td>Self-direction and Self-management</td>
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**Third Year Courses**

**Concept Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>701-2413-00L</td>
<td>Evolutionary Genetics</td>
<td>W</td>
<td>6</td>
<td>4</td>
<td>T. Städler, A. Widmer, S. Fior, M. Fischer, J. Stapley</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 268 of 2416
### Molecular Life of Plants

Y. Barral

| Objective | The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics. |
| Content | Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory. Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher's fundamental theorem. Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation. |
| Lecture notes | Handouts |

#### Literature

- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.
- Creighton, T.E., Proteins, Freeman, (1993)

### Molecular and Structural Biology I: Protein Structure

W. Glockshuber, K. Locher, E. Weber-Ban

| Objective | Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics. |
| Lecture notes | Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching. |
| Literature | Basics:  
- Creighton, T.E., Proteins, Freeman, (1993)  
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.  

#### Literature

- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.
- Creighton, T.E., Proteins, Freeman, (1993)

### Concepts in Modern Genetics

O. Voinnet

| Objective | Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference. This course focuses on the concepts of classical and modern genetics and genomics. |
| Content | The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference. |
| Lecture notes | Scripts and additional material will be provided during the semester. |

#### Literature

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO346 at UZH. Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

### Molecular Life of Plants

S. C. Zeeman, K. Bomblies, O. Voinnet

| Objective | The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence. The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels. The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms. |
| Abstract | The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation). |

#### Literature

Current topics: References will be given during the lectures.
The course "Molecular Life of Plants" will cover the following topics:

- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
  - Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
- Senescence

551-0319-00L Cellular Biochemistry (Part I)  W  3 credits  2V  U. Kutay, G. Neurohr, M. Peter, I. Zemp

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include:
- biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

551-0317-00L Immunology I  W  3 credits  2V  M. Kopf, A. Oxenius

Abstract
Introduction into structural and functional aspects of the immune system.
Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Introduction into structural and functional aspects of the immune system.
Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.
### Nucleic Acids and Carbohydrates

**Note for BSc Biology students:** Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor’s degree.

#### Abstract
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

#### Objective
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

#### Content
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNA; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

#### Lecture notes
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

#### Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

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<th>Subject-specific Competencies</th>
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#### Abstract
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

#### Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

#### Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.
### Block Courses in 1st Quarter of the Semester

**20.9.2022 - 12.10.2022**

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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<td>551-1129-00L</td>
<td>Understanding and Engineering Microbial Metabolism</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>J. Vorholt-Zambelli</td>
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<td>Number of participants limited to 6. The enrolment is done by the D-BIOL study administration.</td>
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<td>This laboratory course has a focus on current research topics in our laboratory related to metabolic engineering, the general understanding of metabolism, and is partially focused on one carbon metabolism. Projects will be conducted in small groups.</td>
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<td>The course aims at introducing technologies to investigate bacterial metabolism and key principles of metabolic engineering. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular genetic, biochemical and analytical techniques including metabolomics. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.</td>
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<td>The course will include topics such as pathway elucidation &amp; engineering and related ongoing research projects in the lab. Experimental work applied during the course will comprise methods such as cloning work &amp; transformation, growth determination, enzyme activity assays, liquid-chromatography mass-spectrometry and dynamic labeling experiments.</td>
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<td>Students will be tutored in their experimental work by an experienced doctoral student. The course will also include a short lecture delivered by M. Hospenthal, providing the theoretical background for the experimental work. Throughout the course, students will receive exercises that further help to explain the theory of the practical work, as well as literature research tasks.</td>
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<td>• Purification, biophysical characterisation and structure determination of pilins</td>
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<td>• Purification, biophysical characterisation and structure determination of proteins and protein complexes involved in natural transformation.</td>
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<td>• Enzymatic activity measurements</td>
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<td>• In silico structural analyses using PyMOL and Chimera</td>
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<td>551-1421-00L</td>
<td>The Mechanisms of Natural Transformation in Competent Gram-Negative Bacteria</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>M. Hospenthal</td>
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<td>Students will carry out defined research projects related to the current research topics of the Hospenthal group. The topics will include protein expression of pilins and/or other competence proteins from Gram-negative bacteria, protein purification using affinity chromatography, crystallisation experiments and analysis of assembled pili by electron microscopy.</td>
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<td>The course should enable students to understand concepts of protein expression, purification and the characterisation of biomolecular interactions. In addition, students will learn some basic principles of X-ray crystallography and electron microscopy.</td>
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<tr>
<td>551-1415-00L</td>
<td>Image-Based Drug Screening in Human Blood for Personalized Medicine</td>
<td>W</td>
<td>6 credits</td>
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<td>B. Snijder, further lecturers</td>
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<td><strong>Abstract</strong></td>
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<td>Image based screening allows to measure in high throughput the phenotype of millions of individual cells to external perturbations. We have recently shown that image-based screening in human blood can help to find active treatments for patients with blood cancers. In this course we will take the students through the entire workflow (to the extent that biosafety regulations allow it).</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>Take the students through the entire workflow from experimental design, to screen, to imaging and analysis. -Learn to design an image-based screening experiment -Observe human blood sample handling -Perform immunofluorescence &amp; automated confocal microscopy -Image analysis and result interpretation -Result presentation</td>
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<td></td>
<td><strong>Literature</strong></td>
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<td><strong>Number of participants limited to 5.</strong></td>
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<tr>
<td>551-0337-00L</td>
<td>Cell Biology of the Nucleus</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>R. Kroschewski, Y. Barral, M. Jagannathan, S. Jessberger, K. Weis</td>
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<td></td>
<td>Number of participants limited to 18. The enrolment is done by the D-BIOL study administration.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Introduction to the organizational principles of the nucleus using budding yeast, drosophila and vertebrate cells as model systems.</td>
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</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 272 of 2416
Objective
The aim of our course is to introduce the students to the organizational principles of the nucleus using budding yeast, drosophila and vertebrate cells as model systems. Emphasis is given to:

- Establishment of nuclear identity and nuclear-cytoplasmic communication
- Reorganization of the nucleus in aging
- Animal cells during the generation of cell diversity and neuronal differentiation

Content
By the end of the course, based on lectures, literature reading and practical lab work, the students will be able to formulate open questions concerning the function of the nucleus. Thus, the students will know about the mechanisms and consequences of nuclear-cytoplasmic compartmentalization, nuclear positioning, DNA clustering in the nucleus and cytoplasm during cell divisions and aging.

Students - in groups of 2 or max. 3 - will be integrated into a research project connected to the subject of the course, within one of the participating research groups.

Lecture notes
Lectures and technical notes will be given and informal discussions held to provide you with the theoretical background.

Literature
There will be optional papers to be read before the course start. They serve as framework orientation for the practical parts of this block course and will be made accessible to you shortly before the course starts on the relevant Moodle site.

Lectures and technical notes will be given and informal discussions held to provide you with the theoretical background.

Literature
There will be optional papers to be read before the course start. They serve as framework orientation for the practical parts of this block course and will be made accessible to you shortly before the course starts on the relevant Moodle site.

551-1525-00L Cancer Progression: Mechanisms, Targets and Therapeutic Approaches

Objective
The enrolment is done by the D-BIOL study administration.

Abstract
This course will consider the pathogenetic landscape of cancer and its progression to metastasis, explore how abnormalities of cellular information management cause cancer and demonstrate how the integrated application of modern profiling technologies, mouse cancer models and human pathology provides a foundation for developing individualized cancer therapeutics.

Objective
Insights into and overview about the genetic and metabolic alterations that underlie different cancer types, the complex cancer cell circuits governing tumor development, progression, and metastasis. Understanding of modern approaches used in contemporary basic and translational cancer research and sophisticated strategies to control individual cancers and combat drug resistance. The course is closely linked to ongoing research projects in the lab to provide the participants with direct insights into current experimental approaches and strategies. Student assessment is a graded performance based on individual performance in the laboratory, a written report of their data and a presentation of a recent paper published in a top ranking international peer reviewed journal that relates to cancer.

551-1149-00L Discovery of Drugs from Blue-Green Algae

Objective
The enrolment is done by the D-BIOL study administration.

Abstract
Natural products have long been used as medicine. Blue-green algae (Cyanobacteria) are particularly renowned for producing compounds with antibacterial, antitumor, and insecticidal properties. In this block course, students explore Switzerland's algal communities in habitats including lakes, marshes, streams, peat and raised bogs, and alluvial and riverine forests.

Objective
The students will receive an introduction to relevant subjects of the secondary metabolism of bacteria. Lectures will include an introduction to blue-green algae natural history, systematics and distribution, natural products and drug discovery, bioprospecting and industrial fermentation, relevant analytical methods, microbial communities and metagenomics. The students will receive training in practical work in a research laboratory as well as scientific literacy skills in the form of a research report and oral presentation.

551-0352-00L Introduction to Mass Spectrometry-Based Proteomics

Objective
The enrolment is done by the D-BIOL study administration.

Abstract
Protein Analysis by Mass Spectrometry

Objective
How to prepare a protein sample for MS analysis (trypsin digestion, C18 clean-up)

Prerequisites / notice
None

551-0421-00L Biology and Ecology of Fungi in Forests

Objective
The enrolment is done by the D-BIOL study administration.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 273 of 2416
Abstract
Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

Objective
Knowledge of the fungi of forest and its ecological significance. Knowing of current methodological research approaches. Self-reliant and creative activities of selected topics of fungi from forests.

Content
Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

Lecture notes
Unterlagen zum Kurs werden abgegeben.

Literature

Prerequisites
Knowledge of the fungi of forest and its ecological significance. Knowing of current methodological research approaches. Self-reliant and creative activities of selected topics of fungi from forests.

notice
Erreichbarkeit mit Tram 14 bis Triemli, danach PTT-Bus 220 oder 350 bis Birmensdorf Sternen/WSL oder mit 59 bis Birmensdorf SBB und mit PTT-Bus eine Station in Richtung Zürich bis Birmensdorf Sternen/WSL.

551-0351-00L Membrane Biology

Objective
The course will introduce the students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course.

Content
Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field.

Lecture notes
No script

Literature
The recommended literature, including reviews and primary research articles, will be provided during the course.

551-1201-00L Computational Methods in Genome and Sequence Analysis

Objective
This course aims to provide students with a comprehensive overview of computational methods for sequence analysis and assist with developing skills for application of computational approaches by experimental biologists in the life sciences.

Content
• Application of Genomic intervals and arrays for sequence analysis with HTSeq
• Accessing genome annotation and retrieving relevant information in Pandas
• Ability to implement a solution to a problem in sequence analysis using Python
• Applying tools for sequence alignment and estimating error rates
• Ability to implement a solution to a problem in sequence analysis using Python
• Accessing genome annotation and retrieving relevant information in Pandas

551-1143-00L Analysis of Human T and B Cell Responses to Infectious Agents

Objective
To learn current methodologies in human immunology through experimental work in the lab. To learn current concepts through lectures and discussion of original papers. Requirement for obtaining the credit points: oral presentation of the research project in a ppt format.

551-0359-00L Plant Biochemistry
Lecturers

Phytopathology

P. A. Kast

Research projects on the model pathogen Salmonella. will be distributed at the beginning of the course

Concepts and Theories

6 credits

ECTS

none.

Communication

Through supervision in small groups (either individually or in groups of two) students learn to conduct experiments in molecular plant biology, interpret the results, record them and communicate them to peers. Students also gain an insight into the larger context of their projects and how they are planned in the longer term.

Practical courses:

6 credits

The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The class with its very dense program consists of the practical course itself and an integrated series of seminar/lecture sessions.

All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

A script will be distributed to the participants on the first day of the course.

Literature

Descriptions of the possible projects including individual reading suggestions will be handed out beforehand.

Block Courses in 3rd Quarter of the Semester

8.11.2022 - 30.11.2022

Number

Title

Type

ECTS

Hours

Lecturers

551-0355-00L

Phytopathology

W

6 credits

7P

M. Maurhofer Bringolf, B. McDonald

Number of participants limited to 12.

The enrolment is done by the D-BIOL study administration.

Abstract

Fundamentals (theoretical and practical) in phytopathology, eg. interaction between plants and plant-pathogenic microorganisms, morphology and lifecycles of plant-pathogenic fungi, evolution of plant-pathogenic fungi, biological control of plant diseases

Objective

Insight into ongoing research projects

Content

Theoretical courses:

Fundamentals of phytopathology, eg. interaction between plants and plant-pathogenic microorganisms, morphology and lifecycles of plant-pathogenic fungi, evolution of plant-pathogenic fungi, biological control of plant diseases

Number of participants limited to 12.

The enrolment is done by the D-BIOL study administration.

Abstract

The course will be taught partly in English, partly in German.

Prerequisites / notice

Teaching language is English and German.

Lecture notes

The course will be taught partly in English, partly in German.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

not assessed

Social Competencies

Communication

assessed

Cooperation and Teamwork

not assessed

Personal Competencies

Critical Thinking

not assessed

529-0739-01L

Biological Chemistry B: New Enzymes from Directed Evolution Experiments

W

6 credits

7P

P. A. Kast, K. Würth-Roderer

Number of participants limited to 14.

The enrolment is done by the D-BIOL study administration.

Abstract

During the block course in the fall semester, we will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. The class with its very dense program consists of the practical course itself and an integrated series of seminar/lecture sessions.

Objective

All technologies used for the experiments will be explained to the students in theory and in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

Content

The class deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel, teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

Lecture notes

A script will be distributed to the participants on the first day of the course.
Students will learn to design, carry out and assess experiments using current biochemical and cell biological strategies to analyze cellular functions. The course consists of practical projects in small groups, theoretical lectures, and tutorial sessions. The students will gain hands-on experience in practical lab work, which includes in vivo studies and biochemical experiments. They will learn to design experiments and use techniques necessary to analyze different aspects of insulin signaling, including physiological actions in whole animals as well as in tissue culture. Through lectures and literature seminars, they will learn about the open questions of insulin signaling research and discuss approaches to address these questions experimentally.

In practical lab projects the students will perform physiological in vivo studies as well as biochemical experiments. Finally, they will learn how to present and discuss their data. Student assessment is a graded semester performance based on individual performance in the laboratory, a written exam and the lab data presentation.

### Prerequisites / notice
This laboratory course will involve experiments that require a tight schedule and, particularly in the second half, very long (!) working days. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

The enrolment is done by the D-BIOL study administration. The maximum number of participants for the laboratory class is limited, but surplus applicants may contact P. Kast directly to have their names added to a waiting list. A valid registration is considered a commitment for attendance of the entire course, as involved material orders and experimental preparations are necessary and, once the class has started, the flow of the experiments must not be interrupted by individual absences. In case of an emergency, please immediately notify P. Kast. For more information see http://www.kast.ethz.ch/teaching.html, from where you can also download a flyer.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

### Literature

### Prerequisites / notice
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Safety concept: https://chab.ethz.ch/studium/bachelor1.html

### Literature

### Prerequisites / notice
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**Objective**
To learn techniques in protein structure prediction, functional prediction and evolutionary analyses (bioinformatic), as well as protein purification from e. coli, insect cell, and/or cell-free systems, and analysis of e.g. interactions with DNA, thermostability, etc...

**Content**
Guided research projects to study the biochemical consequences of adaptive evolution in a variety of proteins. Mostly the focus is on proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.

**Lecture notes**
Will be provided, as appropriate, during the course.

**Literature**
Will be provided during course.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-1119-00L</td>
<td><strong>Microbial Community Genomics</strong></td>
<td>W</td>
<td>6</td>
<td>P</td>
<td>S. Sunagawa</td>
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<td><strong>Number of participants limited to 10.</strong></td>
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<td></td>
<td><strong>Prerequisite: Basic knowledge in [R] (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer.</strong></td>
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<td><strong>The enrolment is done by the D-BIOL study administration.</strong></td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Introduction to current research methods in the analysis of microbial communities using Next Generation Sequencing approaches - metagenomics. Practical experience of work in a computational laboratory and an introduction to scientific programming.</td>
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<td>Gain skills in data analysis and presentation for oral and written reports. Lectures introducing state-of-the-art in respective research areas and community microbiology, which is the target of ongoing research. Start to assess current literature.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td>Basic knowledge in [R] (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer.</td>
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<tr>
<th>Number</th>
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<tr>
<td>551-1147-00L</td>
<td><strong>Bioactive Natural Products from Bacteria</strong></td>
<td>W</td>
<td>6</td>
<td>P</td>
<td>J. Piel</td>
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<td><strong>Number of participants limited to 8.</strong></td>
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<td><strong>The enrolment is done by the D-BIOL study administration.</strong></td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Lab course. In small groups projects of relevance to current research questions in the field of bacterial natural product biosynthesis are addressed.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Introduction to relevant subjects of the secondary metabolism of bacteria. Training in practical work in a research laboratory. Scientific writing in form of a research report.</td>
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<td>Research project on bacteria that produce bioactive natural products (e.g., Streptomycetes, Cyanobacteria, uncultivated bacteria). The techniques used will depend on the project, e.g. PCR, cloning, natural product analysis, precursor feeding studies, enzyme expression and analysis.</td>
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<td><strong>Lecture notes</strong></td>
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<td><strong>Literature</strong></td>
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<td>Will be provided for each of the projects at the beginning of the course.</td>
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**Block Courses in 4th Quarter of the Semester**

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0361-00L</td>
<td><strong>Biology of Bryophytes and Ferns</strong></td>
<td>W</td>
<td>6</td>
<td>P</td>
<td>R. Holdereger, A. L. Bergamini</td>
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<td><strong>Number of participants limited to 16.</strong></td>
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<td><strong>Abstract</strong></td>
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<td>Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes; field trip. Ferns: basic knowledge on the life cycle, morphology, evolution and ecology of ferns; identification of Swiss fern species; field trips.</td>
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<td><strong>Objective</strong></td>
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<tr>
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<td>Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes. Ferns: basic knowledge on the life cycle, morphology, evolution and ecology of ferns; identification of Swiss fern species.</td>
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<td><strong>Content</strong></td>
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<td>Bryophytes: Systematics and morphology of hornworts, liverworts and mosses and additional themes such as ecology, biogeography, diversity and endangerment of bryophytes; one full-day field trip. Ferns: Life cycle and morphology; evolutionary groups of ferns including horsetails and lycopsids; mating systems, micro- and macroevolution; ecology; full-day and half-day field trips.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Hand-outs will be distributed.</td>
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<td><strong>Literature</strong></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Students have to present a poster on a special topic.</td>
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<td>Grade according to poster presentation and contributions during the course.</td>
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<th>Hours</th>
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<tbody>
<tr>
<td>551-1309-00L</td>
<td><strong>RNA-Biology</strong></td>
<td>W</td>
<td>6</td>
<td>P</td>
<td>F. Allain, J. Corn, J. Hall, M. Jinek, S. Jonas, B. Mateescu, R. Santoro, O. Voinnet</td>
</tr>
<tr>
<td></td>
<td><strong>Number of participants limited to 17.</strong></td>
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<td><strong>The enrolment is done by the D-BIOL study administration.</strong></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Introduction to the diversity of current RNA-research at all levels from structural biology to systems biology using mainly model systems like S. cerevisiae (yeast), mammalian cells. The students will obtain an overview about the diversity of current RNA-research. They will learn to design experiments and use techniques necessary to analyze different aspects of RNA biology. Through lectures and literature seminars, they will learn about the burning questions of RNA research and discuss approaches to address these questions experimentally. In practical lab projects the students will work in one of the participating laboratories. Finally, they will learn how to present and discuss their data in an appropriate manner. Student assessment is a graded semester performance based on individual performance in the laboratory, the written exam and the poster presentation.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<tr>
<td></td>
<td>Documentation and recommended literature will be provided at the beginning and during the course.</td>
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<tr>
<td></td>
<td>The course will be taught in English.</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-1511-00L</td>
<td><strong>Parallels Between Tissue Repair and Cancer</strong></td>
<td>W</td>
<td>6</td>
<td>P</td>
<td>S. Werner, H. Gehart, M. Schäfer</td>
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<tr>
<td></td>
<td><strong>Number of participants limited to 20.</strong></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer.</td>
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</table>

Data: 01.11.2022 12:41   Autumn Semester 2022   Page 277 of 2416
To learn the cellular and molecular principles underlying tissue repair processes, in particular in the skin and in the liver, and the parallels and differences to cancer. To learn modern technologies in Molecular and Cellular Biology as well as Histology and to use these technologies to study questions related to mechanisms underlying tissue repair and cancer.

This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer. Experimental approaches include biochemical studies, molecular and cellular studies using cultured cell lines and primary cells, as well as analysis of murine and human tissues.

The course combines practical work with lectures, discussions, project preparations and presentations.

### Literature


### Lecture notes

A script will be distributed to the participants on the first day of the course.

### Objective

The goal of this course is to be familiar with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies on motor proteins. The main focus is 3D image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.

### Content

Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. In this block course, we study dynein motor proteins in cilia. Dynein causes conformational change upon ATP hydrolysis and finally generate ciliary bending motion. Participants will analyze cryo-EM data of cilia and visualize in vivo 3D structure of dynein to learn how motor proteins function in the cell. The goal is to acquire the techniques to image bacteria by electron cryotomography, resolve their structure in a native state, in 3D, and to macromolecular resolution. In a small group, students will perform wet lab experiments, data collection with stat-of-the-art equipment, data processing and analyses. The key method and its application in bacterial cell biology will be introduced by lectures.

### Lecture notes

*Siehe Lernmaterialien*

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### Block Courses in the 1st Half of the Semester

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
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<tr>
<td>701-2437-01L</td>
<td>Aquatic Ecology (Incl. Two Identification Courses)</td>
<td>O</td>
<td>12</td>
<td>3V+6U+4P</td>
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</tbody>
</table>

The course can only be booked via the Biology Office of Student Affairs.
This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, groundwater and lakes.

This course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) as well as excursions.

### Objective

During this course you will get an overview of the world's typical continental aquatic ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat, and how the interactions (e.g. food web) between organisms work.

During the experimental part of this course you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work) and present the collected knowledge.

After this course you will know the most important aquatic species groups (macroinvertebrates, microinvertebrates and freshwater algae) in Switzerland and the most important identification traits.

### Content

The course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) and field excursions.

#### Lecture notes

Course notes and power point presentations provided during the course.

#### Prerequisites / notice

The maximal participating number of biology students is 14.

The course includes a field trip to Greifensee (23.09.2021) and a 3-day-excursion to the river Glatt in Niederuzwil from 29.09. to 01.10.2021.

### 529-0810-01L Laboratory Course Organic Chemistry II

- **W 12 credits 14P C. Thilgen**

  - **Abstract**
    
    An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

  - **Objective**
    
    Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetical research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

  - **Content**
    
    An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

  - **Lecture notes**
    
    No course notes.

  - **Prerequisites / notice**
    
    No set textbooks. Literature will be indicated or provided by the supervising TAs.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
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<tr>
<td>Social Competencies</td>
<td>Project Management</td>
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<tr>
<td>Communication</td>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
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### Block Courses in the 2nd Half of the Semester

#### Autumn Semester 2022

8.11.2022 - 22.12.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12 credits</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

- **Abstract**
  
  This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, groundwater and lakes.

  This course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) as well as excursions.

- **Objective**
  
  During this course you will get an overview of the world's typical continental aquatic ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat, and how the interactions (e.g. food web) between organisms work.

  During the experimental part of this course you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work) and present the collected knowledge.

  After this course you will know the most important aquatic species groups (macroinvertebrates, microinvertebrates and freshwater algae) in Switzerland and the most important identification traits.

- **Content**
  
  The course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) and field excursions.

  **Lecture notes**

  Course notes and power point presentations provided during the course.

  **Prerequisites / notice**

  The maximal participating number of biology students is 14.

  The course includes a field trip to Greifensee (23.09.2021) and a 3-day-excursion to the river Glatt in Niederuzwil from 29.09. to 01.10.2021.
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

No course notes.

The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

This course aims to provide students with a comprehensive overview of mammalian developmental biology and stem cell systems both on the theoretical as well as the experimental level. Centering the course on genetic and genomic methods engages the students in contemporary research and prepares for future studies in the course of semester and master projects.

Genomic and Genetic Methods in Cell and Developmental Biology

Number of participants limited to 8. The enrolment is done by the D-BIOL study administration.

This course provides students with a comprehensive overview of mammalian developmental biology and stem cell systems both on the theoretical as well as the experimental level. Centering the course on genetic and genomic methods engages the students in contemporary research and prepares for future studies in the course of semester and master projects.

The course will consist of a series of lectures, assay assignments, project development and discussion workshops, and 2 and a half week of lab work with different mammalian cell systems embedded in real life research projects. At the end of the course students will take an exam consisting of questions on the topics of the lectures and workshops. It is expected that students will be able to apply the knowledge to concrete problems.

An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

The course aims to provide students with a comprehensive overview of mammalian developmental biology and stem cell systems both on the theoretical as well as the experimental level. Centering the course on genetic and genomic methods engages the students in contemporary research and prepares for future studies in the course of semester and master projects.

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Genomic and Genetic Methods in Cell and Developmental Biology

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The course will consist of a series of lectures, assay assignments, project development and discussion workshops, and 2 and a half week of lab work with different mammalian cell systems embedded in real life research projects. At the end of the course students will take an exam consisting of questions on the topics of the lectures and workshops. It is expected that students will be able to apply the knowledge to concrete problems.
### Concepts of modern genetics and genomics

Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

#### Literature

- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
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<th>Title</th>
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<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voigt</td>
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<tr>
<td>551-0311-00L</td>
<td>Molecular Life of Plants</td>
<td>W</td>
<td>6</td>
<td>S. Zeeman, K. Bombles, O. Voigt</td>
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<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
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<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>U. Kutay, G. Neurohr, M. Peter, I. Zemp</td>
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</table>

### Molecular Life of Plants

The course focuses on the concepts of classical and modern genetics and genomics.

**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.

**Content**

- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
- Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
- Senescence

### Microbiology (Part I)

Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Abstract**

This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Objective**

This new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

**Content**

1.chloroplast biogenesis and light perception
2. photosynthetic and central carbon metabolism
3. integration of carbon and nitrogen metabolism
4. principles of RNA silencing
5. microRNAs: discovery and modes of action
6. RNA silencing and pathogen defense
7. RNA silencing movement, amplification and trans-generational silencing
8. plants and the environment
9. plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
10. senescence

**Literature**

- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.
- Creighton, T.E., Proteins, Freeman, (1993)

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**Please mind the ETH enrolment deadlines for UZH students:**

Objective

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor(s)</th>
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<tr>
<td>551-0318-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
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</table>

Abstract

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Content

- Introduction and historical background
- Innate and adaptive immunity. Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature

- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

551-1299-00L Bioinformatics

Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective

Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

Prerequisites / notice

Course participants have already acquired basic programming skills in UNIX, Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.
Nucleic Acids and Carbohydrates

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

Abstract
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication

Personal Competencies
Adaptability and Flexibility

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication

Personal Competencies
Adaptability and Flexibility

Personal Competencies
Self-awareness and Self-reflection
Self-direction and Self-management


Block Courses


Please note the ETH admission criteria for the admission of ETH students to ETH block courses on the block course registration website under "allocation".

Block Courses in 1st Quarter of the Semester

From 20.9.2022 - 12.10.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-1129-00L</td>
<td>Understanding and Engineering Microbial Metabolism</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>J. Vorholt-Zambelli</td>
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<td></td>
<td>Number of participants limited to 6. The enrolment is done by the D-BIOL study administration.</td>
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Abstract
This laboratory course has a focus on current research topics in our laboratory related to metabolic engineering, the general understanding of metabolism, and is partially focused on one carbon metabolism. Projects will be conducted in small groups.

Objective
The course aims at introducing technologies to investigate bacterial metabolism and key principles of metabolic engineering. The main focus of this block course is on practical work and will familiarize participants with complementary approaches, in particular genetic, biochemical and analytical techniques including metabolomics. Results will be presented by students in scientific presentations. Another goal is to learn how to write a scientific report.

Content
Experimental work applied during the course will comprise methods such as cloning work & transformation, growth determination, enzyme activity assays, liquid-chromatography mass-spectrometry and dynamic labeling experiments.

Lecture notes
None

Literature
None Will be provided at the beginning of the course.

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<th>Number</th>
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<tbody>
<tr>
<td>551-1421-00L</td>
<td>The Mechanisms of Natural Transformation in Competent Gram-Negative Bacteria</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>M. Hospenthal</td>
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<td>Number of participants limited to 5. The enrolment is done by the D-BIOL study administration.</td>
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Abstract
Students will carry out defined research projects related to the current research topics of the Hospenthal group. The topics will include protein expression of pilins and/or other competence proteins from Gram-negative bacteria, protein purification using affinity chromatography, crystallisation experiments and analysis of assembled pili by electron microscopy.

Objective
The course should enable students to understand concepts of protein expression, purification and the characterisation of biomolecular interactions. In addition, students will learn some basic principles of X-ray crystallography and electron microscopy.
Cancer Progression: Mechanisms, Targets and Therapeutic Approaches

Number of participants limited to 15.
The enrolment is done by the D-BIOL study administration.

Abstract
This course will consider the pathogenetic landscape of cancer and its progression to metastasis, explore how abnormalities of cellular information management cause cancer and demonstrate how the integrated application of modern profiling technologies, mouse cancer models and human pathology provides a foundation for developing individualized cancer therapeutics.

Objective
Insights into and overview about the genetic and metabolic alterations that underlie different cancer types, the complex cancer cell circuitries governing tumor development, progression, and metastasis. Understanding of modern approaches used in contemporary basic and translational cancer research and sophisticated strategies to control individual cancers and combat drug resistance. The course is closely linked to ongoing research projects in the lab to provide the participants with direct insights into current experimental approaches and strategies. Student assessment is a graded performance based on individual performance in the laboratory, a written report of their data and a presentation of a recent paper published in a top ranking international peer reviewed journal that relates to cancer.

Literature
Any required reading of literature will be discussed at the beginning of the course.

Prerequisites / notice
There are no special requirements for this course.

551-1415-00L Image-Based Drug Screening in Human Blood for Personalized Medicine

W 6 credits 7P B. Snijder, further lecturers

The enrolment is done by the D-BIOL study administration.

Abstract
Image based screening allows to measure in high throughput the phenotype of millions of individual cells to external perturbations. We have recently shown that image-based screening in human blood can help to find active treatments for patients with blood cancers. In this course we will take the students through the entire workflow (to the extent that biosafety regulations allow it).

Objective
Take the students through the entire workflow from experimental design, to screen, to imaging and analysis.
- Learn to design an image-based screening experiment
- Observe human blood sample handling
- Perform immunofluorescence & automated confocal microscopy
- Image analysis and result interpretation
- Result presentation

Literature
- Relevant study: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30208-9/fulltext
- Editorial commentary: https://www.thelancet.com/journals/lanhae/article/PIIS2352-3026(17)30213-2/fulltext

551-0337-00L Cell Biology of the Nucleus

W 6 credits 7P R. Kroschewski, Y. Barral, M. Jagannathan, S. Jessberger, K. Weis

The enrolment is done by the D-BIOL study administration.

Abstract
Introduction to the organizational principles of the nucleus using budding yeast, drosophila and vertebrate cells as model systems.

Objective
The aim of our course is to introduce the students to the organizational principles of the nucleus using budding yeast, drosophila and vertebrate cells as model systems. Emphasis is given to:
- Establishment of nuclear identity and nuclear-cytoplasmic communication
- Reorganization of the nucleus in aging
- Animal cells during the generation of cell diversity and neuronal differentiation

Content
By the end of the course, based on lectures, literature reading and practical lab work, the students will be able to formulate open questions concerning the function of the nucleus. Thus, the students will know about the mechanisms and consequences of nuclear-cytoplasmic compartmentalization, nuclear positioning, DNA clustering in the nucleus and cytoplasm during cell divisions and aging.

Lecture notes
Lectures and technical notes will be given and informal discussions held to provide you with the theoretical background.

Literature
There will be optional papers to be read before the course start. They serve as framework orientation for the practical parts of this block course and will be made accessible to you shortly before the course starts on the relevant Moodle site.

551-1525-00L Discovery of Drugs from Blue-Green Algae

W 6 credits 7P A. Fraley, J. Piel

Number of participants limited to 3.
The enrolment is done by the D-BIOL study administration.

Objective
Discover the evolutionary and functional plasticity of the nucleus. Thus, the students will know about the mechanisms and consequences of nuclear-cytoplasmic compartmentalization, nuclear positioning, DNA clustering in the nucleus and cytoplasm during cell divisions and aging.

Content
During this block-course, the students will
- learn how organelles establish and maintain identity with a focus on the nucleus
- discover the evolutionary and functional plasticity of the nucleus
- design, apply, evaluate and compare experimental strategies

Students - in groups of 2 or max. 3 - will be integrated into a research project connected to the subject of the course, within one of the participating research groups.

Lecture notes
Lectures and technical notes will be given and informal discussions held to provide you with the theoretical background.

Literature
Documentation and recommended literature (review articles) will be provided during the course.
### Block Courses in 2nd Quarter of the Semester

**From 13.10.2022 - 4.11.2022**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
551-0352-00L | Introduction to Mass Spectrometry-Based Proteomics | W | 6 credits | 7P | L. Gillet, P. Picotti

The enrolment is done by the D-BIOL study administration.

**Abstract**
Protein Analysis by Mass Spectrometry

The following topics will be covered: basics of biological mass spectrometry, including instrumentation, data collection and data analysis; applications to protein identification and characterization; sample preparation methods; proteomics strategies; and quantitative analysis.

**Objective**
How to prepare a protein sample for MS analysis (trypsin digestion, C18 clean-up) Principles of data acquisition LC-MS (QTOF and/or Ion Trap instruments) Perform qualitative proteomic analysis (protein identification with Mascot and/or Sequest Softwares) Perform quantitative proteomic analysis (label-free and labeled analyses)

Analyze/interpret the data to find up/down-regulated proteins

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#### 551-0354-00L

**Introduction to Mass Spectrometry-Based Proteomics**

**Number of participants limited to 12.**

The enrolment is done by the D-BIOL study administration.

**Abstract**
Protein Analysis by Mass Spectrometry

The following topics will be covered: basics of biological mass spectrometry, including instrumentation, data collection and data analysis; applications to protein identification and characterization; sample preparation methods; proteomics strategies; and quantitative analysis.

**Objective**
How to prepare a protein sample for MS analysis (trypsin digestion, C18 clean-up) Principles of data acquisition LC-MS (QTOF and/or Ion Trap instruments) Perform qualitative proteomic analysis (protein identification with Mascot and/or Sequest Softwares) Perform quantitative proteomic analysis (label-free and labeled analyses)

Analyze/interpret the data to find up/down-regulated proteins

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### 551-0345-00L

**Mechanisms of Bacterial Pathogenesis**

**Number of participants limited to 15.**

The enrolment is done by the D-BIOL study administration.

**Abstract**
Research laboratory class in small groups. Research projects on current topics in cellular microbiology and bacterial pathogenesis are assigned to each student.

**Objective**
Introduction to a current topic in cellular microbiology and/or molecular genetics of a bacterial pathogen. Experimental work in the research lab and introduction to the current lab techniques.This includes contributions to the analysis of animal experiment. You will work with the current research literature in bacterial pathogenesis and write a research protocol. Requirement for obtaining the credit points: oral presentation of the research project, a short written exam and evaluation of the research protocol.

**Content**
Research projects on the model pathogen Salmonella.

**Lecture notes**
None.

**Literature**

Additional materials will be provided before the start of the course.

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### 551-0421-00L

**Biology and Ecology of Fungi in Forests**

**Number of participants limited to 10.**

The enrolment is done by the D-BIOL study administration.

**Abstract**
Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

**Objective**
Knowledge of the fungi of forest and its ecological significance. Knowing of current methodological research approaches. Self-reliant and deepened activities of selected topics of fungi from forests.

**Content**
Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

**Lecture notes**

None.

**Literature**


**Prerequisites / notice**

Der Blockkurs findet an der Eidg. Forschungsanstalt WSL in Birmensdorf statt. Der Wald vor der Haustüre des Institutes macht diesen Kurs besonders praxisnah.

Erreichbarkeit mit Tram 14 bis Triemli, danach PTT-Bus 220 oder 350 bis Birmensdorf Sternen/WSL, oder mit S9 bis Birmensdorf SBB und mit PTT-Bus eine Station in Richtung Zürich bis Birmensdorf Sternen/WSL.

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### 551-0351-00L

**Membrane Biology**

**Number of participants limited to 12.**

The enrolment is done by the D-BIOL study administration.

**Abstract**
Natural products have long been used as medicine. Blue-green algae (Cyanobacteria) are particularly renowned for producing compounds with antibacterial, antitumor, and insecticidal properties. In this block course, students explore Switzerland’s algal communities in habitats including lakes, marshes, streams, peat and raised bogs, and alluvial and riverine forests.

**Objective**
The students will receive an introduction to relevant subjects of the secondary metabolism of bacteria. Lectures will include an introduction to blue-green algae natural history, systematics and distribution, natural products and drug discovery, bioprospecting and industrial fermentation, relevant analytical methods, microbial communities and metagenomics. The students will receive training in practical work in a research laboratory as well as scientific literacy skills in the form of a research report and oral presentation.

**Content**
The students will work on a research project focusing on the discovery of bioactive natural products from regional blue-green algae known to produce bioactive molecules. Students will learn from lectures in class, lab and in the field and gain experience with field collection techniques and the sequence of steps required for natural products discovery including organic extraction, fractionation, and column chromatography. They will use analytical techniques such as HPLC and mass spectrometry for initial characterization of the purified secondary metabolites. Primary biological assays will be conducted to identify natural product extracts and fractions with antibiotic activity as a first step in the drug discovery process.

**Lecture notes**
Provided after each lecture.

**Literature**

https://archive.org/details/howtoknowfreshwa00pres

Additional materials will be provided before the start of the course.

**Prerequisites / notice**

None.

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### Data: 01.11.2022 12:41

Autumn Semester 2022

Page 285 of 2416
The course will introduce the students to the key concepts in membrane biology and will allow them to be involved in laboratory projects related to that broad field. The course will consist of lectures, literature discussions, and practical laboratory work in small groups. Results of the practical projects will be presented during the poster session at the end of the course.

The aim of the course is to expose the students to a wide range of modern research areas encompassed by the field of membrane biology. Students will be engaged in research projects aimed at understanding the biological membranes at the molecular, organellar and cellular levels. Students will design and perform experiments, evaluate experimental results, analyze the current scientific literature and understand the relevance of their work in the context of the current state of the membrane biology field.

The course will be taught in English. All general lectures will be held at ETH Hoenggerberg. Students will be divided into small groups to carry out experiments at ETH or at the Paul Scherrer Institute. Travel to the Paul Scherrer Institute will be by public transportation.

**Computational Methods in Genome and Sequence Analysis**

- **Content**: Methods for analyzing animal genomes are increasingly becoming important for applications in human health and biotechnology. The enrolment is done by the D-BIOL study administration.
- **Objective**: This course aims to provide students with a comprehensive overview of computational methods for sequence analysis and assist with developing skills for application of computational approaches by experimental scientists in the life sciences.
- **Prerequisites**:
  - It is recommended to bring your own computer with a Python installation to the course
  - Simple computers can be provided
  - Programming basics with Python

**Analysis of Human T and B Cell Responses to Infectious Agents**

- **Content**: Understanding the anatomy of a real world sequence analysis project, applying tools for sequence alignment and estimating error rates, ability to implement a solution to a problem in sequence analysis using Python, accessing genome annotation and retrieving relevant information in Pandas, application of Genomic intervals and arrays for sequence analysis with HTSeq.
- **Prerequisites**:
  - Number of participants limited to 12.
- **Objective**: Students actively participate in ongoing research projects on the analysis of human T and B cell response to pathogens and vaccines. They will be tutored in small groups by doctoral students and postdocs. The theoretical background of the projects is provided in a lecture series. Finally, students discuss their projects and results during an interactive poster session.

**Plant Biochemistry**

- **Content**: Understanding the information in biological sequences and quantifying similarity, introduction to algorithms for sequence comparison and searches, implementation of sequence comparisons and searches in Python, accessing data formats associated with genome sequence analysis tasks, understanding the anatomy of a real world sequence analysis project, applying tools for sequence alignment and estimating error rates, ability to implement a solution to a problem in sequence analysis using Python, accessing genome annotation and retrieving relevant information in Pandas, application of Genomic intervals and arrays for sequence analysis with HTSeq.
- **Prerequisites**:
  - Number of participants limited to 11.
- **Objective**: To learn current methodologies in human immunology through experimental work in the lab. To learn current concepts through lectures and discussion of original papers. Requirement for obtaining the credit points: oral presentation of the research project in a ppt format.
Methods in Cellular Biochemistry

Number of participants limited to 13.
Teaching language is English and German.

The course deals with a specifically designed and genuine research project. We intend to carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains. By working in parallel, teams of 2 participants each will generate a variety of different variants of a chorismate mutase. Individual enzyme catalysts will be purified and subsequently characterized using several different spectroscopic methods. The detailed chemical-physical analyses include determination of the enzymes' kinetic parameters, their molecular mass, and the integrity of the protein structure. The results obtained from the individual evolution experiments will be compared and discussed at the end of the class in a final seminar. We expect that during this lab course we will not only generate novel enzymes, but also gain new mechanistic insights into the investigated catalysts.

Further literature will be indicated in the distributed script.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Methods in Cellular Biochemistry

Number of participants limited to 13.
The enrolment is done by the D-BIOL study administration.

Abstract
Students will learn about biochemical approaches to analyze cellular functions. The course consists of practical projects in small groups, lectures and literature discussions. The course concludes with the presentation of results at a poster session.

Objective
Students will learn to design, carry out and assess experiments using current biochemical and cell biological strategies to analyze cellular functions in model systems. In particular they will learn novel imaging techniques along with biochemical approaches to understand fundamental cellular pathways. Furthermore, they will learn to assess strengths and limitations of the different approaches and be able to discuss their validity for the analysis of cellular functions.

Literature
Documentation and recommended literature (review articles and selected primary literature) will be provided during the course.
This course will be taught in English.
Proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.

In practical lab projects the students will perform physiological in vivo studies as well as biochemical experiments. Finally, they will learn how to present and discuss their data. Student assessment is a graded semester performance based on individual performance in the laboratory, a written exam and the lab data presentation.

**Abstract**

Introduction to the physiological and biochemical action of insulin signaling and its role in the fasted/feeding response and in obesity and diabetes.

**Objective**

The students will obtain an overview about the current topics of research in insulin signaling and how it impacts on growth, metabolism and cell differentiation. They will learn to design experiments and use techniques necessary to analyze different aspects of insulin signaling, including physiological actions in whole animals as well as in tissue culture. Through lectures and literature seminars, they will learn about the open questions of insulin signaling research and discuss approaches to address these questions experimentally.

In Autumn Semester 2022

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tr>
<td>551-1147-00L</td>
<td>Bioactive Natural Products from Bacteria</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>J. Piel</td>
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<td></td>
<td>Lab course. In small groups projects of relevance to current research questions in the field of bacterial natural product biosynthesis are addressed.</td>
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<td></td>
<td>Introduction to relevant subjects of the secondary metabolism of bacteria. Training in practical work in a research laboratory. Scientific writing in form of a research report.</td>
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<td>Research project on bacteria that produce bioactive natural products (e.g., Streptomycetes, Cyanobacteria, uncultivated bacteria). The techniques used will depend on the project, e.g. PCR, cloning, natural product analysis, precursor feeding studies, enzyme expression and analysis.</td>
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<td></td>
<td>Lecture notes none.</td>
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<td></td>
<td>Literature Will be provided for each of the projects at the beginning of the course.</td>
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<td><strong>Prerequisite:</strong> Basic knowledge in [R] (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer.</td>
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<tr>
<td>551-1119-00L</td>
<td>Microbial Community Genomics</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>S. Sunagawa</td>
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<td>Prerequisite: Basic knowledge in [R] (e.g. introductory course) and/or UNIX is required. Participants should bring their own laptop computer.</td>
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<td>Lecture notes Will be provided, as appropriate, during the course.</td>
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<tr>
<td>551-1517-00L</td>
<td>Protein Change in Adaptive Evolution</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>C. S. Hughes, K. Bombilies, A. P. Nayak</td>
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<td>Number of participants limited to 5.</td>
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<td>Prerequisites: It is recommended to attend the course Lebensmittel-Mikrobiologie (752-4005-00L) as a preparation.</td>
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<td>The course can only be booked via the Biology Student secretariat</td>
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<tr>
<td></td>
<td>Abstract Proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.</td>
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<td>Objective To learn techniques in protein structure prediction, functional prediction and evolutionary analyses (bioinformatic), as well as protein purification from e. coli, insect cell, and/or cell-free systems, and analysis of e.g. interactions with DNA, thermostability, etc…</td>
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<td>Content Guided research projects to study the biochemical consequences of adaptive evolution in a variety of proteins. Mostly the focus is on proteins that seem to have evolved to help stabilize meiosis to temperature and/or polyploidy in plants.</td>
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<td>Lecture notes Handouts were provided at the start of the course</td>
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<td>Literature - Krämer: &quot;Lebensmittel-Mikrobiologie&quot; (Ulmer; UTB)</td>
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<td>- Süssmuth et al.: &quot;Mikrobiologisch-Biochemisches Praktikum&quot; (Thieme)</td>
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<td>During the course we will work with the food-borne pathogen Listeria monocytogenes. Listeria monocytogenes represents a particular threat to pregnant women. Due to biosafety reasons participation is not allowed in case of pregnancy.</td>
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<tr>
<td>752-4020-00L</td>
<td>Experimental Food Microbiology for Biologists</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>M. Schuppler, M. Loessner, Y. Shen</td>
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<td>Number of participants limited to 12</td>
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<td>Prerequisites: It is recommended to attend the course Lebensmittel-Mikrobiologie (752-4005-00L) as a preparation.</td>
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<td></td>
<td>Abstract Teaching of basic experimental knowledge for detection and identification of microorganisms in food. Practical experiments were accompanied by theoretical introductions. Students become acquainted with classical and state-of-the-art molecular techniques for the rapid detection of foodborne pathogens and experiments in dependence on current research topics of the Laboratory of Food Microbiology.</td>
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<td></td>
<td>Objective Introduction of methods and techniques of food microbiology</td>
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<td></td>
<td>Content Teaching of basic experimental knowledge for detection and identification of foodborne pathogens by applying state-of-the-art techniques as well as modern molecular techniques for the rapid identification of relevant foodborne pathogens.</td>
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<td>Literature - Krämer: &quot;Lebensmittel-Mikrobiologie&quot; (Ulmer; UTB)</td>
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### Block Courses in 4th Quarter of the Semester

From 1.12.2022 - 23.12.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0361-00L</td>
<td>Biology of Bryophytes and Ferns</td>
<td>W</td>
<td>6</td>
<td>7P</td>
<td>R. Holderegger, A. L. Bergamini</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 16.</td>
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<td></td>
<td>The enrolment is done by the D-BIOL study administration.</td>
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<tr>
<td></td>
<td>Lab course. In small groups projects of relevance to current research questions in the field of bacterial natural product biosynthesis are addressed.</td>
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<tr>
<td></td>
<td>Introduction to relevant subjects of the secondary metabolism of bacteria. Training in practical work in a research laboratory. Scientific writing in form of a research report.</td>
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<tr>
<td></td>
<td>Research project on bacteria that produce bioactive natural products (e.g., Streptomycetes, Cyanobacteria, uncultivated bacteria). The techniques used will depend on the project, e.g. PCR, cloning, natural product analysis, precursor feeding studies, enzyme expression and analysis.</td>
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<tr>
<td></td>
<td>Lecture notes none.</td>
<td></td>
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<tr>
<td></td>
<td>Literature Will be provided for each of the projects at the beginning of the course.</td>
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</tbody>
</table>
The goal of this course is to be familiar with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies. Hand-outs will be distributed.

This course aims at the understanding of the cellular and molecular mechanisms underlying tissue repair processes in response to different insults. The focus will be on repair of the skin and the liver. In addition, we will highlight the parallels and differences between tissue repair and cancer. Experimental approaches include biochemical studies, molecular and cellular studies using cultured cell lines and primary cells, as well as analysis of murine and human tissues.

In Vivo Cryo-EM Analysis of Dynein Motor Proteins

The goal of this course is to be familiar with structural biology techniques of cryo-electron tomography and single particle cryo-EM studies on motor proteins. The main focus is in vivo image analysis of cryo-EM datasets acquired by highest-end microscopes. Participants will learn structure-function relationship at various scales: how the conformational change of motor proteins causes mechanical force and generates cellular motility.

Ferns: basic knowledge on the life cycle, morphology, evolution and ecology of ferns; identification of Swiss fern species; field trips.

Bryophytes: basic knowledge on the morphology, ecology, biogeography and endangerment of bryophytes; knowledge of common species; skills in the determination of bryophytes; field trip.

Bryophytes: Systematics and morphology of hornworts, liverworts and mosses and additional themes such as ecology, biogeography, diversity and endangerment of bryophytes; one full-day field trip.

Ferns: Life cycle and morphology; evolutionary groups of ferns including horsetails and lycopods; mating systems, micro- and macroevolution; ecology; full-day and half-day field trips.

The course is taught in English.

Grade according to poster presentation and contributions during the course.
Motor proteins, such as dynein, myosin and kinesin, hydrolyze ATP to ADP and phosphate to convert chemical energy to mechanical motion. Their function is essential for intracellular transport, muscle contraction and other cellular motility as well as cell division. Motor proteins have been major targets of biophysical studies. There exist questions from atomic to tissue levels – how ATP hydrolysis causes conformational change of motor proteins; how their motion is regulated by calcium, phosphorylation and other factors; how motions of multiple motor proteins are coordinated to generate cellular motility. Structural biology has been playing central roles to answer these questions. X-ray crystallography and single particle cryo-EM address structural analysis at atomic resolution and try to reveal molecular mechanism of conformational change. Cryo-electron tomography analyze localization and 3D structure of motor proteins in the cell to explain how motions of molecular motors happen in the context of cellular environment and are integrated into cellular motion. In this course, we study dyneins in cilia. Cilia are force-generating organelles, made by microtubules and thousands of dyneins. Dynein hydrolyzes ATP and undergoes conformational change, generating linear motion with respect to the microtubule. As a whole system, cilia integrate motions of these dyneins and orchestrate beating motion. To explain ciliary motion at molecular level, we need to know dynein conformational change in the cellular context. Cryo-electron tomography is recently developed technique to study molecular structures in vivo and therefore a suitable method to study dynein in cilia. Recently spatial resolution of these cryo-EM techniques was dramatically improved, driven by development of new types of detectors and electron optics. The participants of this course will learn a program to analyze cryo-electron tomography and single particle cryo-EM data, acquired by highest-end electron microscopes and detectors in ETH and other places, and reconstruct 3D structure (tomogram) of cilia from various organisms (from green algae to human). They will further learn a program to study molecular structures from these tomograms (called subtomogram averaging) and apply it to reconstruct high-resolution 3D structure of dyneins, microtubules and regulatory proteins. This practical course is therefore mainly computational, but we will also provide students a chance of cilia preparation from green algae, cryo-EM data collection using an electron microscope in PSI and site-visit of highest-end electron microscope facility in ETH.

**Course notes and power point presentations provided during the course.**

**Aquatic Ecology (Incl. Two Identification Courses)**

**7P**

Characterization of the Aggregation Landscape of Short peptide amyloids are models for their more complex protein counterparts in the study of disease-related and functional aggregation structures as well as assay their ability to template their own chemical synthesis.

**Abstract**

- Short peptide amyloids are models for their more complex protein counterparts in the study of disease-related and functional aggregation structures as well as being interesting in their own right as molecules that may have played a role in the origin of life. This block course will allow the students to study novel peptides in order to characterize their aggregation landscape and also to assess the ability to template their own chemical synthesis.

**Objective**

- The course is divided between lectures practical work in the lab. The lectures will introduce the general topic of amyloids and in particular their potential role in the origin of molecular complexity, as well as cover the theory and the practical behind the tools that are used to characterize peptide amyloids. The practical work in the lab will allow the students to gain hands-on experience working on a novel peptide that has yet to be characterized. Since the course consists of genuine research we also hope that new discoveries will be made that will provide insights into the role that amyloids may have played in the origin of life.

**Content**

- The course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) and field excursions.

**Lecture notes**

- A script will be distributed to the participants on the first day of the course.

**Literature**

- Further literature will be indicated in the distributed script.

### Block Courses in the 1st Half of the Semester

**From 20.9.2022 - 4.11.2022**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-2437-01L</td>
<td><strong>Aquatic Ecology (Incl. Two Identification Courses)</strong>&lt;br&gt;The course can only be booked via the Biology Office of Student Affairs</td>
<td>W</td>
<td>12</td>
<td>3V+6U+4P</td>
<td>J. Jokela, P. Spaak, F. Altermatt, A. Narwani, F. Pomati, C. T. Robinson</td>
</tr>
</tbody>
</table>

- **Abstract**
  - This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, groundwater and lakes.

- **Objective**
  - During this course you will get an overview of the world's typical continental aquatic ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat, and how the interactions (e.g. food web) between organisms work.
  - During the experimental part of this course you will learn the principles of doing research to observe interrelations in aquatic ecosystems.
  - You will measure and interpret biological and physical data (e.g. during experiments, field work) and present the collected knowledge.
  - After this course you will know the most important aquatic species groups (macroinvertebrates, microinvertebrates and freshwater algae) in Switzerland and the most important identification traits.

- **Content**
  - The course contains a lecture part, an experimental part, two determination courses (aquatic invertebrates and algae) and field excursions.
  - The lecture part covers ecology and evolution of aquatic organisms in lentic and lotic waters. Topics include: Adaptations, distribution patterns, biotic interactions, and conceptual paradigms in freshwater ecosystems; important aspects regarding ecosystem metabolism and habitat properties of freshwater; applied case studies and experiments testing ecological and evolutionary processes in freshwater.

- **Prerequisites / notice**
  - Admittance is limited and depends on the availability of student places.

- **Enrolment**
  - The enrolment is done by the D-BIOL study office.

### Laboratory Course Organic Chemistry II

<table>
<thead>
<tr>
<th>Number</th>
<th><strong>Laboratory Course Organic Chemistry II</strong>&lt;br&gt;- Admittance is limited and depends on the availability of student places</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0810-01L</td>
<td></td>
<td>W</td>
<td>12</td>
<td>14P</td>
</tr>
</tbody>
</table>

- **Prerequisites / notice**
  - The maximal participating number of biology students is 14.

- **Objective**
  - The course includes a field trip to Greifensee (23.09.2021) and a 3-day-excursion to the river Glatt in Niederuzwil from 29.09. to 01.10.2021.
hosting research labs.
- Interested students are asked to contact Prof. C. Thilgen (thilgen@org.chem.ethz.ch) before the end of the preceding semester for further details.
- In case of admittance, the actual enrolment needs to be done via the D-BIOL study administration.

Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective
Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Self-presentation and Social Influence</td>
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</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Integreity and Work Ethics</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Project Management</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.

Block Courses in the 2nd Half of the Semester
8.11.2022 - 22.12.2022

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0810-01L</td>
<td>Laboratory Course Organic Chemistry II</td>
<td>W</td>
<td>12 credits</td>
<td>14P</td>
<td>C. Thilgen</td>
</tr>
</tbody>
</table>

- Interested students are asked to contact Prof. C. Thilgen (thilgen@org.chem.ethz.ch) before the end of the preceding semester for further details.

- In case of admittance, the actual enrolment needs to be done via the D-BIOL study administration.

Abstract
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Objective
Learn to plan and carry out challenging multistep syntheses making use of modern methods; reach a deeper understanding of organic reactions through experimental work; develop an organic-synthetic research project; take accurate notes, write a publication style report, and present the obtained results in a seminar.

Content
An organic-synthetic sub-project of the current research of a group from the Laboratory of Organic Chemistry is carried out under the guidance of doctoral students.

Fostered competencies

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<th>Personal Competencies</th>
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<tbody>
<tr>
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<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Self-presentation and Social Influence</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Integreity and Work Ethics</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Project Management</td>
<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>

Prerequisites / notice
Course prerequisites: Accomplished laboratory course Organic Chemistry I (529-0229-00 or 529-0016-00) and passed session exams Organic Chemistry I (529-0221-00 or 529-1011-00) / Organic Chemistry II (529-0222-00 or 529-1012-00). The number of participants per course is limited to 4.

Fostered competencies

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<td></td>
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<td></td>
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<td>Project Management</td>
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<td></td>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

Autumn Semester 2022
### Block Courses during the Semester Break

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-1709-00L</td>
<td>Genomic and Genetic Methods in Cell and Developmental Biology</td>
<td>W</td>
<td>6 credits</td>
<td>7P</td>
<td>A. Wutz, M. Kopf, T. Schroeder</td>
</tr>
</tbody>
</table>

**Abstract**
This course aims to provide students with a comprehensive overview of mammalian developmental biology and stem cell systems both on the theoretical as well as the experimental level. Centering the course on genetic and genomic methods engages the students in contemporary research and prepares for future studies in the course of semester and master projects.

**Objective**
- Understanding mammalian development
- Introduction to stem cells systems
- Working with cultured cells
- Translational aspects of mammalian cell biology

**Content**
The course will consist of a series of lectures, assay assignments, project development and discussion workshops, and 2 and a half week of lab work with different mammalian cell systems embedded in real life research projects. At the end of the course students will take an exam consisting of questions on the topic of the lectures and workshops. It is expected that students will be able to apply the knowledge to concrete problems.

### Science in Perspective

#### Science in Perspective

**see Science in Perspective: Type A: Enhancement of Reflection Capability**

**Recommended Science in Perspective (Type B) for D-BIOL**

#### Language Courses

**see Science in Perspective: Language Courses ETH/UZH**

### Biology Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
<th>W</th>
<th>Eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tr>
</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
# Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-06L</td>
<td><strong>Cognitively Activating Instructions in MINT Subjects</strong></td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td>Abstract</td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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</tbody>
</table>
| Objective    | - Get to know cognitively activating instructions in MINT subjects  
- Get information about recent literature on learning and instruction |      |       |       |                            |
| Prerequisites / notice | Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht. |      |       |       |                            |
|              | see Educational Science Teaching Diploma    |      |       |       |                            |
| 851-0242-07L | **Human Intelligence**                      | W    | 1 credit | 1S   | E. Stern                    |
|              | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |      |       |       |                            |
|              | Number of participants limited to 30.      |      |       |       |                            |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)". |      |       |       |                            |
| Abstract     | The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed. |      |       |       |                            |
| Objective    | - Understanding of research methods used in the empirical human sciences  
- Getting to know intelligence tests  
- Understanding findings relevant for education |      |       |       |                            |
| 851-0242-08L | **Research Methods in Educational Science** | W    | 1 credit | 2S   | C. M. Thurn, T. Braas, P. Edelsbrunner |
|              | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |      |       |       |                            |
|              | Number of participants limited to 30.      |      |       |       |                            |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)". |      |       |       |                            |
| Abstract     | Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work. |      |       |       |                            |
| Objective    | - Understand research methods used in the empirical educational sciences  
- Understand and critically examine information from scientific journals and media  
- Understand pedagogically relevant findings from the empirical educational sciences |      |       |       |                            |
| 851-0242-11L | **Gender Issues In Education and STEM**     | W    | 2 credits | 2S   | M. Berkowitz Biran, T. Braas, C. M. Thurn |
|              | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |      |       |       |                            |
|              | Number of participants limited to 30.      |      |       |       |                            |
| Prerequisite | students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it. |      |       |       |                            |
| Abstract     | In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed. |      |       |       |                            |
| Objective    | - To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues  
- To develop a critical view on existing research and perspectives.  
- To integrate this knowledge with teacher’s work. |      |       |       |                            |
| Content      | Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them. |      |       |       |                            |
| The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar. |      |       |       |                            |
| Prerequisites / notice | Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1). |      |       |       |                            |
| 851-0229-00L | **Using Outdoor Education**                 | W    | 1 credit | 1S   | R. Schumacher, P. Faller   |
|              | Enrolment only possible with matriculation in Teaching Diploma Biology and Geography. |      |       |       |                            |
| Abstract     | In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf. |      |       |       |                            |
Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

Subject Didactics in Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0961-00L</td>
<td>Mentored Work Subject Didactics Biology A</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>P. Faller, H. Stocker</td>
</tr>
<tr>
<td></td>
<td>The Subject Didactics as well as possible branch-specific requirements must be fulfilled prior to commencing the mentored paper.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures. Under supervision, they compile tuition materials enabling effective learning and/or analyse and reflect on certain topics from a subject-based and pedagogical perspective.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The objectives for the students are</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics, pedagogical, and potentially social perspective.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- to prove that they can independently compile a tuition sequence and develop it to deployment.</td>
<td></td>
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<tr>
<td>Content</td>
<td>Thematic Schwerpunkte</td>
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<tr>
<td></td>
<td>Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.</td>
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<tr>
<td>Lecture notes</td>
<td>Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.</td>
<td></td>
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<tr>
<td>Prerequisites / notice</td>
<td>Beginn nach Absprache jederzeit möglich, jedoch erst nach Abschluss der Fachdidaktik I und II und nach Erfüllung allfälliger fachwissenschaftlicher Auflagen.</td>
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<thead>
<tr>
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<tbody>
<tr>
<td>551-0962-00L</td>
<td>Mentored Work Subject Didactics Biology B</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>P. Faller, H. Stocker</td>
</tr>
<tr>
<td></td>
<td>The Subject Didactics as well as possible branch-specific requirements must be fulfilled prior to commencing the mentored paper.</td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures. Under supervision, they compile tuition materials enabling effective learning and/or analyse and reflect on certain topics from a subject-based and pedagogical perspective.</td>
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<tr>
<td>Objective</td>
<td>The objectives for the students are</td>
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<td></td>
<td>- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics, pedagogical, and potentially social perspective.</td>
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<td></td>
<td>- to prove that they can independently compile a tuition sequence and develop it to deployment.</td>
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<tr>
<td>Content</td>
<td>Thematic Schwerpunkte</td>
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<td></td>
<td>Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.</td>
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<tr>
<td>Lecture notes</td>
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<td>Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Beginn nach Absprache jederzeit möglich, jedoch erst nach Abschluss der Fachdidaktik I und II und nach Erfüllung allfälliger fachwissenschaftlicher Auflagen.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0971-00L</td>
<td>Subject Didactics Biology I</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>P. Faller</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in Introductory Internship Biology</td>
<td></td>
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<tr>
<td>Abstract</td>
<td>- Basic conditions for tuition (MAR - recognition of Matura certificates - curricula, standards), selection of topics and reduction of the complexity of topics.</td>
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<td></td>
<td>- Application of teaching methods and techniques from educational science in biology classes.</td>
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<td></td>
<td>- Planning and preparation of lessons.</td>
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<tr>
<td>Objective</td>
<td>- Students can discuss and put into practice in their teaching work the conditions and objectives set out in the regulations governing the school-leaving examination (Matura), the framework curriculum and the conditions and objectives specified by their school.</td>
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<td></td>
<td>- They are in a position to select learning objectives and formulate these on the basis of the target level model. They can plan and prepare lessons and can also develop appropriate learning assignments.</td>
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<td>- Students can reconstruct specialist contents in didactic terms and develop teaching modules suitable for the different levels from these on the basis of the subject structure and learner requirements.</td>
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<td>- They can redress the complexity of subject-based specialist contents and present them in such a way that they are comprehensible and meaningful for learners.</td>
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<td>- They can select appropriate media for their work (e.g. school books) and use these. They can employ appropriate experiments.</td>
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<td>- The students can use different forms of examination for monitoring performance.</td>
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<td></td>
<td>- Students are in a position to implement and discuss the concepts of biology teaching and learning on the basis of specific topics covered in school biology.</td>
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</tbody>
</table>
### Professional Training

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0968-00L</td>
<td>Introductory Internship Biology ☑</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>P. Faller</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in Biology Didactics I - course 551-0971-00L - is compulsory.</td>
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<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.</td>
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<tr>
<td>Objective</td>
<td>Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training.</td>
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<tr>
<td>Literature</td>
<td>Wird von der Praktikumslehrperson bestimmt.</td>
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<tr>
<td>551-0966-00L</td>
<td>Teaching Internship Biology ☑</td>
<td>O</td>
<td>8</td>
<td>17P</td>
<td>P. Faller</td>
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<tr>
<td></td>
<td>Simultaneous enrolment in Biology Didactics II - course 551-0972-00L - is compulsory.</td>
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<tr>
<td>Abstract</td>
<td>The teaching practice takes place in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.</td>
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<tr>
<td>Objective</td>
<td>- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching. - They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils. - They acquire the skills of the teaching trade. - They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution. - They learn to assess pupils' work. - Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.</td>
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<tr>
<td>Literature</td>
<td>Wird von der Praktikumslehrperson bestimmt.</td>
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<tr>
<td>Prerequisites</td>
<td>Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.</td>
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<tr>
<td>551-0969-01L</td>
<td>Examination Lesson I Biology ☑</td>
<td>O</td>
<td>1</td>
<td>2P</td>
<td>P. Faller</td>
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<tr>
<td></td>
<td>Simultaneous enrolment in &quot;Examination Lesson II Biology&quot; (551-0969-02L) is compulsory.</td>
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<tr>
<td>Abstract</td>
<td>In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.</td>
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<tr>
<td>Objective</td>
<td>- On the basis of a specified topic, the candidate shows that they are in a position - to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle - to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.</td>
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<tr>
<td>551-0969-02L</td>
<td>Examination Lesson II Biology ☑</td>
<td>O</td>
<td>1</td>
<td>2P</td>
<td>P. Faller</td>
</tr>
<tr>
<td></td>
<td>Simultaneous enrolment in &quot;Examination Lesson I Biology&quot; (551-0969-01L) is compulsory.</td>
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<tr>
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</table>

**Data:** 01.11.2022 12:41  
**Autumn Semester 2022**  
**Page 295 of 2416**
After successful completion of the module, students should be able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter. They can incorporate these experiments in their tuition in a didactically meaningful manner. Students can perform, off the cuff, 12 school experiments (which they have tested themselves), from the different subject areas, and conduct these correctly in technical terms. They can incorporate these experiments in their tuition in a didactically meaningful manner. By contrast to the Subject Specialisation 1 and 2 course units, these are "basic tests" and do not involve the implementation of current research topics. The students' compilations are available in a data archive.

2. Die Studierenden führen alle ausgearbeiteten Experimente selber durch.

Hand out of course material.

The Specialized Biology Course with an Educational Focus consists of two modules (6 CP each). In the fall semester, the focus is on evolution. The module of the spring semester deals with biological concepts. Students attending both modules can start with either module.

Performance is assessed during the course of the entire module. Active participation in the course is required. The thesis (including oral presentation) has to be completed.

In case of overbooking of the course, students enrolled in the Teaching Diploma in Biology will have priority.

### Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0180-00L</td>
<td>Research Ethics  <img src="https://example.com" alt="" /></td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>G. Achermann, P. Emch</td>
</tr>
</tbody>
</table>

Particularly suitable for students of D-BIOL, D-CHAB, D-HEST.

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Participants of the course Research Ethics will

- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people's arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;


<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
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<tr>
<td>551-0973-00L</td>
<td>Specialized Biology Course with an Educational Focus: Evolution <img src="https://example.com" alt="" /></td>
<td>O</td>
<td>6</td>
<td>2G+13A</td>
<td>H. Stocker, Y. Barral, K. Köhler</td>
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</tbody>
</table>

Specialist aspects of biology with a focus on evolution are covered from the angle of imparting these to pupils, their historical development, and their significance for the subject, the individual and society.

After successful completion of the module, students should be able

- to retrieve in-depth knowledge of biology with a special focus on evolution and to impart this to others.
- to analyse controversial topics and to give factual explanations for these.
- to conduct more in-depth work on a research topic and to compile a tuition unit based on this topic.
- to prepare tuition units involving complex learning matter at a high specialist level which are suitably tailored to the recipients, and to teach these in a manner conducive to learning.

Selected biological topics, with a special focus on evolution, are dealt with under consideration of the special needs of persons involved in teaching.

The module comprises lectures, a book club, and a seminar thesis. The module lectures comprises lectures, a book club, and a seminar thesis. The module lectures comprises lectures, a book club, and a seminar thesis.
I. Introduction to Moral Reasoning
1. Ethics - the basics
1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision-making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!)
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…)

Fostered competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
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<td>assessed</td>
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<td>assessed</td>
<td>assessed</td>
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<tr>
<td>Ownership of data</td>
<td>Retention of data</td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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</table>

| 701-0015-00L | Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement |
| W | 2 credits | 2S |

B. Vienni Baptista, C. E. Pohl, M. Stauffacher

Abstract
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants’ research projects more societally relevant.

Objective
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader societal impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content
The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) The specific challenges of inter- and transdisciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants' research projects more societally relevant
Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.
Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

The following open access article builds a core element of the course:

To analyze the evolution as well as the key elements of environmental governance.

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors’ behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of ‘environmental governance’ and how legitimate and effective are these approaches in addressing persistent environmental challenges?

A detailed course schedule will be made available at the beginning of the semester.

During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy).

The following open access article builds a core element of the course:


The following open access article builds a core element of the course:

The following open access article builds a core element of the course:

The following open access article builds a core element of the course:
The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.

At the end of the course, students:
- know core concepts of sustainable development, main features of social justice in the context of sustainability, a selection of methodologies for the assessment of sustainable development
- have a deepened understanding of the challenges of trade-offs between the different dimensions of sustainable development and their respective impacts on individual and societal decision-making

The course is structured as follows:
- overview of rationale, objectives, concepts and origins of sustainable development (approx. 15%)
- overview of the concept of social justice as guiding principle of the social dimension of sustainability (approx. 20%)
- analysis of a selection of concepts and methodologies to assess sustainable development in a variety of contexts (approx. 65%)

Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L)

Using Outdoor Education

Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.

This seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

This course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Selected scientific articles and book-chapters

Prerequisites / notice
This course will take place on campus (ETH Main Building, HF F.3).

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Course Units for Additional Admission Requirements

The courses below are only available for students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>

Abstract
Basic knowledge of the anatomy and physiology of tissues, of the embryonal and postnatal development, the sensory organs, the neuromuscular system, the cardiovascular system and the respiratory system.

Objective
Basic knowledge of human anatomy and physiology and basics of clinical pathophysiology.
The lecture series provides a short overview of human anatomy and physiology

**Anatomy and Physiology I (fall term):**
Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system.

**Anatomy and Physiology II (spring term):**
Digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.

### Prerequisites / notice
Requirements: 1st year, scientific part. Part of the course is read and checked in English.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course</th>
<th>Semester</th>
<th>Credits</th>
<th>Type</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>752-4001-00L</td>
<td>Microbiology</td>
<td>E-</td>
<td>2</td>
<td>V</td>
<td>M. Ackermann, M. Schuppler, J. Vorholt-Zambelli</td>
</tr>
<tr>
<td>551-0127-01L</td>
<td>Plants and Fungi</td>
<td>E-</td>
<td>4</td>
<td>G</td>
<td>S. C. Zeeman, M. Künzler, O. Y. Martin</td>
</tr>
</tbody>
</table>

**Abstract**
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

**Objective**
1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity.
2. Students can explain how the internal and external structures of fungi and plants function to support survival, growth, behavior, and reproduction.
3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development).
4. Students can describe how a single cell develops from one cell into many, each with different specialized functions.

**Content**
The lecture introduces the structural and functional specialization in fungi and plants. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi and plants have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.

**Literature**
Alberts et al. 'Molecular Biology of the Cell' 6th edition
Campbell "Biology", 11th Edition

**Prerequisites / notice**
Some lecture are held in English.
Biology Master

Elective Major Subject Areas

Elective Major: Ecology and Evolution

Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-2413-00L</td>
<td>Evolutionary Genetics</td>
<td>O</td>
<td>6</td>
<td>4V</td>
<td>T. Städler, A. Widmer, S. Fior, M. Fischer, J. Stapley</td>
</tr>
</tbody>
</table>

Abstract
The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Objective
The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content
Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory. Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossing over, effects on fitness; Fisher’s fundamental theorem. 

Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation

Lecture notes
Handouts

Literature

Elective Compulsory Master Courses

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1409-00L</td>
<td>Research Seminar: Ecological Genetics</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>S. Fior</td>
</tr>
</tbody>
</table>

Minimum number of participants is 5.

Abstract
In this research seminar we will critically discuss recent publications on current topics in Ecological Genetics.

Objective
It is our aim that participants gain insight into recent research topics and approaches in Ecological Genetics and learn to critically assess and appreciate scientific publications in this field.

Lecture notes
none

Literature
will be distributed

Prerequisites / notice
Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course.

It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
</tr>
</tbody>
</table>

Abstract
This is an introductory class on insect ecology. During the course you will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes lectures, small group discussions and outside readings.

Objective
The aim of the course is to gain an understanding of how insects have specialised and adapted to occupy diverse environmental niches and become vital to ecosystem processes. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions and examining insect ecology in an evolutionary context.

Lecture notes
Provided to students through Moodle

Literature
Selected required readings (peer reviewed literature). Optional recommended readings with additional information.

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorial and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorial and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>M. Dettling</td>
</tr>
</tbody>
</table>

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.
Literature

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Self-presentation and Social Influence</td>
<td>Integrity and Work Ethics</td>
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<td>Concept of R</td>
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<tr>
<td>Analytical</td>
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701-0301-00L Applied Systems Ecology

Number of participants limited to 35. Waiting list will be deleted 02.10.2022.

Abstract

This course provides the ecological systems’ knowledge needed to question applied solutions to current environmental issues. Our central aim is to balance participants’ respect for complexity with a sense of possibility by providing examples from the vast solution space offered by ecological systems, such as green infrastructure to manage water.

Objective

...you know how to structure your inquiry and how to proceed the analysis when faced with a complex environmental issue. You can formulate the relevant questions, find answers (supported by discussions, input from the lecturers and the literature), and you are able to present your conclusions clearly and cautiously.
...you understand the complexity of interactions and structures in ecosystems. You know how ecosystem processes, functions and services interact and feed back across multiple spatio-temporal scales (in general, plus in depth case examples).
...you understand that biodiversity and the interaction between organisms are an integral part of ecosystems. You are aware that the link between biodiversity and process/function/service is rarely fully understood. You know how to honestly deal with this lack of understanding and can nevertheless find, critically analyse and communicate solutions.
...you understand the importance of ecosystem services for society.
...you have an overview of the methods of ecosystem research and have a deeper insight into some of them, e.g. ecosystem observation, manipulation and modelling.
...you have reflected on ecology as a young discipline at the heart of significant applied questions.

Content

This course provides the ecological systems’ knowledge needed to question applied sustainability solutions. We will critically assess the complexity of current environmental issues, illustrating basic ecological concepts and principles. Our central aim is to balance participants’ respect for complexity with a sense of possibility by providing examples from the vast solution space offered by ecological systems, such as green infrastructure to manage water.

The course is structured around four larger topical areas: (1) Integrated Water Management -- Green infrastructure (land management options) as an alternative to engineered solutions (e.g. large reservoirs) in flood and drought management; (2) Fire dynamics, the water cycle and biodiversity -- The surprising dynamics of species life cycles and populations in arid landscapes; (3) Rewilding, e.g. reintroducing apex predators (e.g. wolves), or large ungulates (e.g. bisons) in protected areas -- A nature conservation trend with counterintuitive effects; (4) Coupling of aquatic and terrestrial systems: carbon, nitrogen and phosphorus transfers of global importance on landscape scale.

Lecture notes

Case descriptions, commented glossary and a list of literature and further resources per case.

Literature


Prerequisites / notice

The course combines elements of a classic lecture, group discussions and problem based learning. It is helpful, but not essential to be familiar with the “seven stages” method (see e.g. course 701-0352-00L "Analysis and Assessment of Environmental Sustainability" by Christian Pohl et al.).

401-6215-00L Using R for Data Analysis and Graphics (Part I)

W 1.5 credits 1G

Abstract

The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

Objective

The students will be able to use the software R for simple data analysis and graphics.
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
The course resources will be provided via the Moodle web learning platform. Subscribing via Mystudies "automatically" makes you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=18279

Fostered competencies

<table>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<td>Analytical Competencies</td>
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401-6217-00L Using R for Data Analysis and Graphics (Part II) W 1.5 credits 1G M. Mächler

Abstract
The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

Objective
The students will be able to use the software R efficiently for data analysis, graphics and simple programming

Content
The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tailoring R: options
- Extending basic R: packages

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
Basic knowledge of R equivalent to "Using R .. (Part I)" (= 401-6215-00L ) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should "automatically" make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15522

751-4504-00L Plant Pathology I W 2 credits 2G B. McDonald

Abstract
Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.

Objective
Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

**Week 1**  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

**Week 2**  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

**Week 3**  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gull, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

**Week 4**  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytotoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

**Week 5**  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defences, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

**Week 6**  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.


**Week 8**  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

**Week 9**  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

**Week 10**  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.

**Week 11**  Strategies for minimizing disease risks: lowering epidemic risk, ecological risk assessment, natural and synthetic pesticides. Disease control strategies: economic thresholds, overview of control strategies.

**Week 12**  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

**Week 13**  Cultural control methods: fertilizers, crop rotations.

**Week 14**  Open lecture.

Lecture notes
Detailed lecture notes (~160 pages) will be available for purchase at the end of the semester.

**636-0017-00L Computational Biology**

**W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Stadler**

**Abstract**
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

**Objective**
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

**Content**
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GAWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phyloynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

**Lecture notes**
Lecture slides will be available on moodle.

**Literature**
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

**Prerequisites / notice**
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

**701-1471-00L Ecological Parasitology**

**W 3 credits 1V+1P F. A. A. Feijen, J. Jokela.**
Abstract
Course focuses on the ecology and evolution of macro parasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

Practical exercises:
1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

Prerequisites / notice
The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

701-1703-00L Evolutionary Medicine for Infectious Diseases

Number of participants limited to 35.

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:
- Evolutionary Parasitology
- Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

636-0009-00L Evolutionary Dynamics

Abstract
Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

Objective
The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Content
Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

Lecture notes
No.

Literature

Prerequisites / notice
Prerequisites: Basic mathematics (linear algebra, calculus, probability)

Fostered competencies
Subject-specific Competencies
Concepts and Theories
assessed
Method-specific Competencies
Analytical Competencies
assessed
Problem-solving
assessed
Social Competencies
Communication
not assessed
Cooperation and Teamwork
not assessed
Personal Competencies
Critical Thinking
assessed
Self-direction and Self-management
not assessed

701-0328-00L Advanced Ecological Processes

For students of the following study programmes only:
Biology Master
Teaching certificate Biology
Environmental Sciences Master
UZH MNF Biology
UZH MNF Geography /Earth Sciences

Abstract
This course presents theoretical and empirical approaches to understanding the ecological processes structuring populations and communities. Central problems covered include species interactions, spatial structure, resource dynamics, and ecological responses to environmental change. These and other topics will be explored from basic and applied perspectives.
Students will understand how ecological processes operate in natural communities. They will appreciate how mathematical theory, field experimentation, and observational studies combine to generate a predictive science of ecological processes, and how this predictive science informs conservation and management decisions.

Upon completing the course, students will be able to:

Understand the factors determining the outcome of species interactions in communities, and how this information informs management.

Apply theoretical knowledge on species interactions to predict the potential outcomes of novel species introductions.

Understanding the role of spatial structure in mediating population dynamics and persistence, species interactions, and patterns of species diversity.

Use population and community models to predict the stability of interactions between predators and prey and between different competitors.

Understand the conceptual basis of predictions concerning how ecological communities will respond to global change.

Discuss the types of conceptual advances ecology as a science can realistically achieve, and how these relate to the applications of the discipline.

Lectures supplemented with readings from the primary literature and occasional computer exercises will focus on understanding central processes in community ecology. Topics will include demographic and spatial structure, consumer resource interactions, food webs, competition, mutualism, invasion, the maintenance of species diversity, and species effects on ecosystem processes. Each of these more conceptual topics will be discussed in concert with their applications to the conservation and management of species and communities in a changing world.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
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<td>Objective</td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Cooperation and Teamwork</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Communication</td>
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**Selective Concept Courses**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W. D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>
### Abstract
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, bioinformatics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

### Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

### Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

### Fostered competencies

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<td>Analytical Competencies</td>
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<td>Creative Thinking</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>Critical Thinking</td>
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<td>Problem-solving</td>
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<td>Integrity and Work Ethics</td>
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<td>Project Management</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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### Elective Major: Microbiology and Immunology

#### Compulsory Concept Courses

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<tr>
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<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

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For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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### Elective Compulsory Master Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td><strong>551-0223-00L</strong></td>
<td>Immunology III</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>M. Kopf, S. B. Freigang, S. R. Leibundgut, F. Mair, A. Oxenius, C. Schneider, R. Spörri, L. Tortola, E. Wetter Slack</td>
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</table>

**Abstract**

This course provides a detailed understanding of:
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

**Objective**

Obtain a detailed understanding of:
- the development, activation, and differentiation of different types of T cells and their effectormechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naïve B cells to antibody producing plasma cells and memory B cells,
- Optimization of B cell responses by intelligent design of new vaccines

**Content**

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

**Literature**

Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

**Prerequisites / notice**

Immunology I and II recommended but not compulsory

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<tr>
<td><strong>551-0512-00L</strong></td>
<td>Current Topics in Molecular and Cellular Neurobiology</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>U. Suter</td>
</tr>
</tbody>
</table>

**Abstract**

The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

**Objective**

The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

**Content**

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

**Lecture notes**

Presentations will be made available after the seminars.

**Prerequisites / notice**

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

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<tr>
<td><strong>551-1117-00L</strong></td>
<td>Cutting Edge Topics: Immunology and Infection Biology</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>A. Oxenius, B. Becher, C. Halin Winter, M. Kopf, S. R. Leibundgut, C. Münz, L. Tortola, M. van den Broek</td>
</tr>
</tbody>
</table>

**Abstract**

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO636 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-

---
Abstract

Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.

Objective

Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.

Content

Immunology and infection biology.

Lecture notes

The specific topics are variable and depend each semester on the list of invited experts.

Literature

Often parts of the presented seminars have already been published by the respective speakers and the respective primary research can be retrieved from scientific journals.

Fostered competencies

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Systems Biology of Metabolism

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective

Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics.

Lecture notes

Script and original publications will be supplied during the course.

Immunology: From Milestones to Current Topics

Milestones in Immunology: on old concepts and modern experiments

Objective

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Content

Milestones and current topics of innate immunity, antigen presentatin, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

Lecture notes

Original and review articles will be distributed by the respective lecturer.

Immunology: From Milestones to Current Topics

Number of participants limited to 15.

Abstract

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

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Lecture notes

Original and review articles will be distributed by the respective lecturer.

Immunology: From Milestones to Current Topics

Number of participants limited to 15.
Objective

Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry.

Content

Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

Literature

The literature will be provided during the course.

Prerequisites / notice

The course will be taught in English.

752-4009-00L  Molecular Biology of Foodborne Pathogens  W  3 credits  2V  M. Loesener, M. Schmelcher, M. Schuppler, E. Wetter Slack
Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Prerequisites / notice

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-5103-00L  Functional Microorganisms in Foods  W  3 credits  2G  C. Lacroix, A. Geirnaert, A. Greppi
Abstract

This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective

To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content

This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Lecture notes

Copy of the power point slides from lectures will be provided.

Literature

A list of topics for group projects will be supplied, with key references for each topic.

Prerequisites / notice

This lecture requires strong basics in microbiology.

751-4504-00L  Plant Pathology I  W  2 credits  2G  B. McDonald
Abstract

Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.

Objective

Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

### Content

- **Objective**: Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
  - stochastic models in molecular evolution
  - phylogenetic & phylodynamic inference
  - maximum likelihood and Bayesian statistics

- **Content**: The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

- **Literature**: The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
  - Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

- **Lecture notes**: Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

- **Prerequisites / notice**: Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms. Students will be able to (ii) evaluate how evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Waiting list will be deleted 02.10.2022.

Number of participants limited to 35.

This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective

Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature

The focus is on primary literature, but for some parts the following text books provide good background information:

- Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-4005-00L</td>
<td>Food Microbiology I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Loessner</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-2413-00L</td>
<td>Evolutionary Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>T. Städler, A. Widmer, S. Fior, M. Fischer, J. Stapley</td>
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</table>

Abstract

The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

Objective

The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

Content

Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics; neutral theory of molecular evolution and basics of coalescent theory. Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossesbreeding, effects on fitness; Fisher's fundamental theorem. Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

Lecture notes

Handouts

Literature

The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates physiology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence. The advanced course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels. The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms. The course "Molecular Life of Plants" will cover the following topics:

- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
- Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
- Senescence

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.
- Creighton, T.E., Proteins, Freeman, (1993)

Current topics: References will be given during the lectures.

Concepts in Modern Genetics
Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Cellular Biochemistry (Part I)

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to understand the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.
Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.
Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

551-1299-00L Bioinformatics

Abstract
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to answer contemporary questions in the field of biology.

Prerequisites / notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Fostered competencies

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<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Techniques and Technologies</td>
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<td>Cooperation and Teamwork</td>
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529-0731-00L Nucleic Acids and Carbohydrates
W 6 credits 3G K. Lang, P. A. Kast, S. J. Sturla, H. Wennemers

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor’s degree.

Abstract
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Fostered competencies

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Elective Major: Cell Biology

Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, G. Neurohr, M. Peter, I. Zemp</td>
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Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.
Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

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551-0309-00L Concepts in Modern Genetics

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree/courses/special-students/special-students-university-of-zurich.html

Objective
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Content
This course focuses on the concepts of classical and modern genetics and genomics.

Abstract
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

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551-0317-00L Immunology I

Objective
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and regulation of an immune response.

Content
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and regulation of an immune response.

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication

Personal Competencies
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

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551-1299-00L Bioinformatics

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and regulation of an immune response.

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and regulation of an immune response.

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving

Social Competencies
Communication

Personal Competencies
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

---
Abstract
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, bioinformatics and
bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical
and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

Objective
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome
and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with
them to address contemporary questions in the field of biology.

Prerequisites /
notice
Course participants have already acquired basic programming skills in UNIX, Python and R.

Fostered
competencies
Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Objective
The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health
Sciences, will present a paper from the recent literature.

Content
You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the
papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a
discussion of their significance.

Lecture notes
Presentations will be made available after the seminars.

Prerequisites /
notice
You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute
oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a
contribution based on your active participation in discussion of other presentations (10%).

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<tr>
<th>Number</th>
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<td>Neurobiology</td>
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<td>of participants limited to 8.</td>
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<td>Abstract</td>
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<td>The course is a seminar or &quot;journal club&quot;.</td>
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<td>Each Friday a student, or a member of the</td>
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<td>developments in the fields of cellular</td>
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<td>and molecular neurobiology. It also</td>
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<td>fits into the wider literature in the field.</td>
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<td>2</td>
<td>2V</td>
<td>A. Hajnal, D. Bopp</td>
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<td>function to evolutionary changes</td>
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<td>- present and discuss a relevant evolutionary</td>
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<td>- select and integrate key concepts in</td>
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<td>animal evolution from primary literature</td>
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<td>- participate in discussions on topics</td>
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<td>551-1117-00L</td>
<td>Cutting Edge Topics: Immunology and Infection</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>A. Oxenius, B. Becher,</td>
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<td>Biology</td>
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<td>C. Halin Winter, M. Kopf,</td>
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<td>S. R. Leibundgut, C. Münz,</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 316 of 2416
Courses/Special Students/Special Students University of Zurich.html

Abstract
Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion.

Objective
Weekly seminar about cutting edge topics in immunology and infection biology. Internationally renowned experts present their current research followed by an open discussion. The aim of this course is to confront students with current research topics and with scientific presentation. The course offers the opportunity to gain in depth knowledge about diverse topics which are often only briefly touched in the concept courses and to engage in discussion with experts in the field.

Content
Immunology and infection biology. The specific topics are variable and depend each semester on the list of invited experts.

Lecture notes
Current research data (often not yet published) are presented in this seminar series. There is no script and we are not allowed to record or distribute the contents of the seminars. Thus, the ability of students to extract the most relevant points of each seminar is promoted, which is an important skill for the future attendance of scientific meetings.

Literature
Often parts of the presented seminars have already been published by the respective speakers and the respective primary research can be retrieved from scientific journals.

Fostered competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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551-1153-00L Systems Biology of Metabolism

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<th>Number of participants limited to 15.</th>
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Abstract
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content
The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes
Script and original publications will be supplied during the course.

Prerequisites / notice
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

551-1171-00L Immunology: From Milestones to Current Topics

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<th>Number of participants limited to 15.</th>
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Abstract
Milestones in Immunology: on old concepts and modern experiments

Objective
The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Content
Milestones and current topics of innate immunity, antigen presentation, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

Lecture notes
Original and review articles will be distributed by the respective lecturer.

Literature
Literaturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app.let.ethz.ch/course/view.php?id=15568

Fostered competencies

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<th>Concepts and Theories</th>
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<td>Self-presentation and Social Influence</td>
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551-1303-00L Cellular Biochemistry of Health and Disease

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<th>Number of participants limited to 20.</th>
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Abstract
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 317 of 2416
Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry.

Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

The literature will be provided during the course. The course will be taught in English.

**RNA Biology Lecture Series I: Transcription & Processing & Translation**

**Objective:**

The students should obtain an understanding of these processes, which are at work during gene expression.

**Content:**

Transcription & 3'end formation; splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP biogenesis & nuclear export, miRNA surveillance & miRNA turnover; signal transduction & RNA.

**Prerequisites / notice:**

Basic knowledge of cell and molecular biology.

**RNA Biology Lecture Series II: Non-Coding RNAs:**

**Objective:**

This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

**Content:**

Micro RNAs: computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; TRNA biology.

**Prerequisites / notice:**

Basic knowledge of cell and molecular biology.

**Immunology III**

**Objective:**

Obtain a detailed understanding of:

- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological textbook knowledge has evolved.

**Content:**

- development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naïve B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

**Literature:**

Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581

**Cell Biophysics**

**Objective:**

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life's mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.
Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Lecture notes

Theory and corresponding exercises are merged together during the classes.

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of

- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Fostered competencies

- Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed
- Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed
- Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed
- Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

376-1305-01L Neural Systems for Sensory, Motor and Higher Brain Functions

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO343 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degrees/courses/special-students-special-students-university-of-zurich.html

Abstract

The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

Objective

The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.

Content

The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.

Literature

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle / OLAT.

376-1305-00L Development of the Nervous System (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.
Objective
On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills
On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIC0344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
BIO142 Developmental Biology, BIO143 Neurobiology

529-0733-02L Chemical Biology and Synthetic Biochemistry W 6 credits 3G K. Lang

Abstract
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

Objective
After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vitro, C) Critically analyze and assess current chemical biology articles and D) Question the approaches learned and apply them to new biological problems.

Content
principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries); principles of genetic code expansion (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing);
chemical biology of ubiquitin and targeted protein degradation

Lecture notes
A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature
Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice
Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Analytical Competencies assessed

Decision-making not assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Social Competencies

Communication not assessed

Cooperation and Teamwork not assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence not assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Adaptability and Flexibility not assessed

Creative Thinking assessed

Critical Thinking assessed

Integrity and Work Ethics not assessed

Self-awareness and Self-reflection not assessed

Self-direction and Self-management not assessed

551-0309-00L Concepts in Modern Genetics W 6 credits 4V Y. Barral, D. Bopp, A. Hajnal, O. Voinnet

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html/

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.
### Bioinformatics

**Abstract**
Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

**Objective**
Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

**Prerequisites / notice**
Course participants have already acquired basic programming skills in UNIX, Python and R.

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

### Immunology I

**Abstract**
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**
Electronic access to the documentation will be provided. The link can be found at “Lernmaterialien”

**Literature**
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

**Prerequisites / notice**
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

### Cellular Biochemistry (Part I)

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

### Elective Compulsory Master Courses

See D-BIOL Master Studies Guide

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0571-00L</td>
<td>From DNA to Diversity (University of Zurich)</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Hajnal, D. Bopp</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: BIO336</td>
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<td>Mind the enrolment deadlines at UZH: <a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline_s.html">https://www.uzh.ch/cmsssl/en/studies/application/deadline_s.html</a></td>
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<tr>
<td>Abstract</td>
<td>The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analysed model organisms.</td>
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<tr>
<td>Objective</td>
<td>By the end of this module, each student should be able to:</td>
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<tr>
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<td>- recognize the universal principles underlying the development of different animal body plans.</td>
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<td>- explain how the genes encoding the molecular toolkit have evolved to create animal diversity.</td>
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<td></td>
<td>- relate changes in gene structure or function to evolutionary changes in animal development.</td>
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<td></td>
<td>Key skills: By the end of this module, each student should be able to:</td>
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<tr>
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<td>- present and discuss a relevant evolutionary topic in an oral presentation.</td>
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<td>- select and integrate key concepts in animal evolution from primary literature.</td>
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<td></td>
<td>- participate in discussions on topics presented by others.</td>
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| 551-1303-00L | Cellular Biochemistry of Health and Disease |
|             | Number of participants limited to 20. |
| Abstract    | During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies. |
| Objective   | Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry. |
| Content     | Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternately take on the role of discussion leaders throughout the term. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics. |
| Literature  | The literature will be provided during the course. |
| Prerequisites / notice | The course will be taught in English. |
| 551-1153-00L | Systems Biology of Metabolism |
|             | Number of participants limited to 15. |
| Abstract    | Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts. |
| Objective   | Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology. |
| Content     | The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics. |
| Lecture notes | Script and original publications will be supplied during the course. |
| Prerequisites / notice | The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry. |
| 551-1171-00L | Immunology: From Milestones to Current Topics |
|             | 4 credits |
| Abstract    | The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry. |
Objective

The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Content

Milestones and current topics of innate immunity, antigen presenting, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology. 

Lecture notes

Original and review articles will be distributed by the respective lecturer.

Literature

Literaturunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Analytical Competencies</td>
<td>Communication</td>
</tr>
<tr>
<td>assessed</td>
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<td>not assessed</td>
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<tr>
<td>assessed</td>
<td>not assessed</td>
<td>Self-presentation and Social Influence</td>
<td>Self-presentation and Social Influence</td>
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<td>not assessed</td>
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<td>Self-awareness and Self-reflection</td>
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<td>not assessed</td>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>

752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loesener, M. Schmelcher, M. Schuppler, E. Wetter Slack

Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature

Recommendations will be given in the first lecture

Prerequisites / notice

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

376-0300-00L Translational Science for Health and Medicine W 3 credits 2G J. Goldhahn, C. Wolfrum

Abstract

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

Objective

After completing this course, students will be able to understand: Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)

Content

What is translational science and what is it not? How to identify need? - Disease concepts and consequences for research: Basics about incidence, prevalence etc., and orphan indications How to choose the appropriate research type and methodology - Ethical considerations including ethics application - Pros and cons of different types of research - Coordination of complex approaches incl. timing and resources How to measure success? - Outcome variables - Improving the translational process Challenges of communication? How independent is translational science? - Academic boundary conditions vs. industrial influences Positive and negative examples will be illustrated by distinguished guest speakers.

701-1703-00L Evolutionary Medicine for Infectious Diseases W 3 credits 2G A. Hall

Number of participants limited to 35.

Abstract

This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective

Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content

We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature

The focus is on primary literature, but for some parts the following text books provide good background information:

- Schmid Hempel 2011 Evolutionary Parasitology
- Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

Waiting list will be deleted 02.10.2022.
Biological Engineering and Biotechnology

**Abstract**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**

**Lecture notes**
Handout during the course.

**551-1407-00L**
RNA Biology Lecture Series I: Transcription & Processing & Translation

**Abstract**
This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

**Objective**
The students should obtain an understanding of these processes, which are at work during gene expression.

**Content**
Transcription & 3'end formation; splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP biogenesis & nuclear export, miRNA surveillance & mRNA turnover; signal transduction & RNA.

**Prerequisites / notice**
Basic knowledge of cell and molecular biology.

**551-1409-00L**
RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

**Abstract**
This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

**Objective**
The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

**Content**
Micro RNAs: computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; TRNA biology. http://www.nccr-rna-and-disease.ch/tiki-index.php?page=LectureSeries

**Prerequisites / notice**
Basic knowledge of cell and molecular biology.

**376-1305-01L**
Neural Systems for Sensory, Motor and Higher Brain Functions

**Abstract**
The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

**Objective**
The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and optimization of B cell responses by intelligent design of new vaccines. Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objectives
- Obtain a detailed understanding of development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
- Recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- Events and signals for maturation of naïve B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines.

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg).
- NK T cells and responses to lipid antigens.
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17.
- Overview of cytokines and their effector function.
- Co-stimulation (signals 1-3).
- Dendritic cells.
- Evolution of the "Danger" concept.
- Cells expressing Pattern Recognition Receptors and their downstream signals.
- T cell function and dysfunction in acute and chronic viral infections.

Literature
Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites
Immunology I and II recommended but not compulsory.

Elective Major: Biochemistry

Elective Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>O</td>
<td>3 credits</td>
<td>2V</td>
<td>U. Kutay, G. Neurohr, M. Peter, I. Zemp</td>
</tr>
</tbody>
</table>

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

Content
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials (alicia.smith@bbiol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Compulsory Master Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>551-1303-00L</td>
<td>Cellular Biochemistry of Health and Disease</td>
<td>O</td>
<td>4 credits</td>
<td>2S</td>
<td>V. Korkhov, T. Ishikawa, M. Jagannathan, R. Kroschewski, G. Neurohr, M. Peter, A. E. Smith, B. Snijder, K. Weis</td>
</tr>
</tbody>
</table>

Abstract
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

Objective
Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry.

Content
Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

Literature
The literature will be provided during the course.

Prerequisites
The course will be taught in English.

Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

Abstract: Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein folding and structural biology.

Objective: Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytcs.

Lecture notes: Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature: Basics:
- Creighton, T.E., Proteins, Freeman, (1993)

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BI0348 at UZH.

Abstract: Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective: This course focuses on the concepts of classical and modern genetics and genomics.

Content: The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes: Scripts and additional material will be provided during the semester.

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### Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni, M. Zampieri</td>
</tr>
</tbody>
</table>

Abstract: Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective: Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content: The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes: Script and original publications will be supplied during the course.

Prerequisites / notice: The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
</tbody>
</table>


Objective: The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content: Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

Lecture notes: http://www.csb.ethz.ch/education/lectures.html


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### Autumn Semester 2022

Data: 01.11.2022 12:41
Objective

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes

A script will be available.

Literature

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Fostered competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies

Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies

Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Abstract

Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective

Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content

Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation.

Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging.

Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes

Lecture notes will be made available online.

Prerequisites / notice

Information about relevant literature will be available in the lecture & in the lecture notes.

Exercises are an integral part of the lecture.

Prerequisites:

529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)

Fostered competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies

Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies

Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

W 6 credits 3G
R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano

Biological Engineering and Biotechnology

W 4 credits 3V
M. Fussenegger
Abstract

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content


Lecture notes

Handout during the course.

551-1407-00L  RNA Biology Lecture Series I: Transcription & Processing & Translation

W  4 credits  2V  F. Allain, N. Ban, S. Jonas, U. Kutay, further lecturers

Abstract

This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Objective

The students should obtain an understanding of these processes, which are at work during gene expression.

Content

Transcription & 3'end formation; splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP biogenesis & nuclear export, mRNA surveillance & mRNA turnover; signal transduction & RNA.

Prerequisites / notice

Basic knowledge of cell and molecular biology.

551-1409-00L  RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

Does not take place this semester.

W  4 credits  2V  J. Hall, M. Stoffel, further lecturers

Abstract

This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

Objective

The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

Content

Micro RNAs: computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs: nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programming of genome remodelling in ciliates; telomerase and telomeres; tRNA biology.

Prerequisites / notice

Basic knowledge of cell and molecular biology.

227-0939-00L  Cell Biophysics

W  6 credits  4G  T. Zambelli

Abstract

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Content

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

Literature


Prerequisites / notice

Participants need a good command of

• differentiation and integration of a function with one or more variables (basics of Analysis),

• Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 328 of 2416
<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
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<td></td>
<td>Analytical Competencies</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>Problem-solving</td>
<td>Project Management</td>
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<td>Media and Digital Technologies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>Project Management</td>
<td>assessed</td>
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**551-0357-00L Cellular Matters: From Milestones to Open Questions**

**W 4 credits 2S**


Abstract

In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Objective

In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

Content

In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leveres on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:

1) A short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.

2) A research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Lecture notes

The presentations will be made available after the lectures.

Literature

The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

The number of participants is limited to 22 and will only take place with a minimum of 11 participants.

Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using in the subject: 551-0357-00.

In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

Prerequisites / notice
Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Abstract
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

Objective
After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

Content
principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries); principles of genetic code expansion (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing); chemical biology of ubiquitin and targeted protein degradation

Lecture notes
A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature
Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice
Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Ferry, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.
Concepts in Modern Genetics

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Microbiology (Part I)

Abstract
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Prerequisites / notice
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

Immunology I

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Objective
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.
The course "Molecular Life of Plants" will cover the following topics:

**Abstract**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Objective**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Content**
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

**Literature**
Mainly based on original literature, a detailed list will be distributed during the lecture.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Problem-solving</td>
<td>Cooperation and Teamwork</td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

**Lecture notes**
No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

**Elective Major: Molecular Plant Biology**

**Compulsory Master Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0120-00L</td>
<td>Plant Biology Colloquium (Autumn Semester)</td>
<td>W</td>
<td>2</td>
<td>1K</td>
<td>S. C. Zeeman, K. Bomblies, C. Sánchez-Rodríguez, O. Voinnet</td>
</tr>
</tbody>
</table>

**Abstract**
This compulsory course is required only once. It may be taken in autumn as course 551-0120-00 "Plant Biology Colloquium (Autumn Semester)" or in spring as course 551-0120-01 "Plant Biology Colloquium (Spring Semester)".

**Objective**
Current topics in Molecular Plant Biology presented by internal and external speakers from academia.

**Content**

**Compulsory Concept Courses**

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0311-00L</td>
<td>Molecular Life of Plants</td>
<td>O</td>
<td>6</td>
<td>4V</td>
<td>S. C. Zeeman, K. Bomblies, O. Voinnet</td>
</tr>
</tbody>
</table>

**Abstract**
The advanced course introduces students to plants through a concept-based discussion of developmental processes that integrates morphology and biochemistry with genetics, molecular biology, and cell biology. The course follows the life of the plant, starting with the seed, progressing through germination to the seedling and mature plant, and ending with reproduction and senescence.

**Objective**
The new course "Molecular Life of Plants" reflects the rapid advances that are occurring in the field of experimental plant biology as well as the changing interests of students being trained in this discipline. Contemporary plant biology courses emphasize a traditional approach to experimental plant biology by discussing discrete topics that are removed from the context of the plant life cycle. The course will take an integrative approach that focuses on developmental concepts. Whereas traditional plant physiology courses were based on research carried out on intact plants or plant organs and were often based on phenomenological observations, current research in plant biology emphasizes work at the cellular, subcellular and molecular levels.

The goal of "Molecular Life of Plants" is to train students in integrative approaches to understand the function of plants in a developmental context. While the course focuses on plants, the training integrative approaches will also be useful for other organisms.

**Content**
The course "Molecular Life of Plants" will cover the following topics:

- Plant genome organization and evolution
- Plant functional genomics and systems biology
- Plant genome engineering and editing
- Seed development and embryogenesis
- Root apical meristem: structure, function and hormone regulation
- Shoot apical meristem: structure, function and hormone regulation
- Mobilization of seed reserves
- Heterotrophic to autotrophic growth
- Chloroplast biogenesis and light perception
- Photosynthetic and central carbon metabolism
- Integration of carbon and nitrogen metabolism
- Principles of RNA silencing
- MicroRNAs: discovery and modes of action
- RNA silencing and pathogen defense
- RNA silencing movement, amplification and trans-generational silencing
- Plants and the environment
- Plant-pathogen interactions: pathogen attack, first layers of plant defense and plant responses
- Senescence

**Elective Compulsory Concept Courses**

See D-BIOL Master Studies Guide

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

**Abstract**
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Content
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Lecture notes
Updated handouts will be provided during the class.

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

551-0319-00L
Cellular Biochemistry (Part I)
3 credits
2V
U. Kutay, G. Neurohr, M. Peter, I. Zemp

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Content
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Lecture notes
Scripts and additional material will be provided during the semester.

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.
### Elective Compulsory Master Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>751-5121-00L</td>
<td>Insect Ecology</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>C. De Moraes, N. Stanczyk</td>
</tr>
<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4 credits</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni, M. Zampieri</td>
</tr>
</tbody>
</table>

#### Insect Ecology
- **Abstract**: This is an introductory class on insect ecology. During the course you will learn about insect interactions with, and adaptations to, their environment and other organisms, and the importance of insect roles in our ecosystems. This course includes lectures, small group discussions and outside readings.
- **Objective**: The aim of the course is to gain an understanding of how insects have specialised and adapted to occupy diverse environmental niches and become vital to ecosystem processes. Important topics include: insect-plant interactions, chemical ecology, predator-prey interactions, vectors of disease, social insects, mutual and parasitic interactions and examining insect ecology in an evolutionary context.
- **Lecture notes**: No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).
- **Literature**: Mainly based on original literature, a detailed list will be distributed during the lecture.
- **Fostered competencies**: Concepts and Theories assessed, Techniques and Technologies assessed, Analytical Competencies assessed, Problem-solving assessed, Communication assessed, Cooperation and Teamwork assessed, Self-awareness and Self-reflection assessed, Self-direction and Self-management assessed.

#### Systems Biology of Metabolism
- **Number**: 551-1153-00L
- **Title**: Systems Biology of Metabolism
- **Type**: W
- **ECTS**: 4
- **Hours**: 2V
- **Lecturers**: U. Sauer, N. Zamboni, M. Zampieri

- **Abstract**: Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.
- **Objective**: Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.
- **Content**: The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.
- **Lecture notes**: Script and original publications will be supplied during the course.
- **Prerequisites / notice**: The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

#### Plant Pathology I
- **Number**: 751-4504-00L
- **Title**: Plant Pathology I
- **Type**: W
- **ECTS**: 2
- **Hours**: 2G
- **Lecturers**: B. McDonald

- **Abstract**: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.
- **Objective**: Students will understand: 1) how pathogens attack plants and, 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.
Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.

Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.

Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.

Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytotoxins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.

Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).

Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bio). Pathogen effects on food quality. Positive and negative transformations.


Week 8  Epidemiology: Disease pyramid, environmental effects on epidemiological development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.

Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.

Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.


Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.

Week 13  Cultural control methods: fertilizers, crop rotations.

Week 14  Open lecture.

Lecture notes

Detailed lecture notes (~160 pages) will be available for purchase at the cost of reproduction at the start of the semester.

551-1407-00L  RNA Biology Lecture Series I: Transcription & Processing & Translation

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>Basic knowledge of cell and molecular biology.</td>
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<tr>
<td>Does not take place this semester.</td>
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</table>

551-1409-00L  RNA Biology Lecture Series II: Non-Coding RNAs:

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic knowledge of cell and molecular biology.</td>
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<tr>
<td>Does not take place this semester.</td>
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</table>

529-0733-02L  Chemical Biology and Synthetic Biochemistry

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>A script will not be handed out. Handouts to the lecture will be provided through moodle.</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 335 of 2416
Prerequisites / notice
Knowledge provided in the bachelor lectures ‘Nucleic Acids and Carbohydrates’ and ‘Proteins and Lipids’ is assumed for this lecture.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
<tr>
<td></td>
<td>(D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course)</td>
<td></td>
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<tr>
<td>Abstract</td>
<td>Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Scripts on the individual topics can be found under <a href="http://www.mol.biol.ethz.ch/teaching">http://www.mol.biol.ethz.ch/teaching</a>.</td>
<td></td>
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</tr>
</tbody>
</table>
| Literature  | Basics:  
- Creighton, T.E., Proteins, Freeman, (1993)  
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.  
Current topics: References will be given during the lectures. |

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
<tr>
<td>Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.</td>
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<tr>
<td>Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html</a></td>
<td></td>
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<tr>
<td>Abstract</td>
<td>Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<tr>
<td>Objective</td>
<td>This course focuses on the concepts of classical and modern genetics and genomics.</td>
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<tr>
<td>Content</td>
<td>The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<tr>
<td>Lecture notes</td>
<td>Scripts and additional material will be provided during the semester.</td>
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</thead>
<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
<tr>
<td>Abstract</td>
<td>Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Objective</td>
<td>This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Content</td>
<td>Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.</td>
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<tr>
<td>Lecture notes</td>
<td>Updated handouts will be provided during the class.</td>
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<tr>
<td>Literature</td>
<td>Current literature references will be provided during the lectures.</td>
<td></td>
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</tbody>
</table>
| Prerequisites / notice | English  
The lecture “Grundlagen der Biologie II: Mikrobiologie” is the basis for this advanced lecture. |

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, G. Neurohr, M. Peter, I. Zemp</td>
</tr>
<tr>
<td>Abstract</td>
<td>Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division &amp; growth, and cell migration.</td>
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</tbody>
</table>
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Abstract
Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

Content
We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Objective
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective

Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes

Script and original publications will be supplied during the course.

Prerequisites / notice

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

Elective Compulsory Master Courses II: Biology

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-1153-00L</td>
<td>Systems Biology of Metabolism</td>
<td>W</td>
<td>4 credits</td>
<td>2V</td>
<td>U. Sauer, N. Zamboni, M. Zampieri</td>
</tr>
<tr>
<td>551-0571-00L</td>
<td>From DNA to Diversity (University of Zurich)</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>A. Hajnal, D. Bopp</td>
</tr>
<tr>
<td>636-0009-00L</td>
<td>Evolutionary Dynamics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U+2A</td>
<td>N. Beerenwinkel</td>
</tr>
</tbody>
</table>

**Abstract**

The course is given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

**Objective**

By the end of this module, each student should be able to:
- Recognize the fundamental principles underlying the development of different animal body plans.
- Explain how the genes encoding the molecular toolkit have evolved to create animal diversity.
- Relate changes in gene structure or function to evolutionary changes in animal development.
- Key skills: By the end of this module, each student should be able to:
  - Present and discuss a relevant evolutionary topic in an oral presentation.
  - Select and integrate key concepts in animal evolution from primary literature.
  - Participate in discussions on topics presented by others.

**Content**

Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

**Objective**

The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

**Content**

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

**Prerequisites / notice**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

**Literature**


**Prerequisites**

Basic mathematics (linear algebra, calculus, probability)

**Fostered competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

<table>
<thead>
<tr>
<th>Number</th>
<th>Cell Biophysics</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0939-00L</td>
<td>Cell Biophysics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>
Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective
Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann’s law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes
No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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Elective Major: Molecular and Structural Biology

Compulsory Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>O</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
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</table>

D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 340 of 2416
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epi-genetics and RNA interference.

Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

Elective Compulsory Concept Courses

See D-BIOL Master Studies Guide

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>551-0319-00L</td>
<td>Cellular Biochemistry (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>U. Kutay, G. Neurohr, M. Peter, I. Zemp</td>
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<tr>
<td>Abstract</td>
<td>Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division &amp; growth, and cell migration.</td>
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<tr>
<td>Objective</td>
<td>The full-year course (551-0319-00 &amp; 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.</td>
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<td>Content</td>
<td>Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.</td>
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<tr>
<td>Lecture notes</td>
<td>Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (<a href="mailto:alicia.smith@bc.biol.ethz.ch">alicia.smith@bc.biol.ethz.ch</a>)</td>
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<tr>
<td>Literature</td>
<td>Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.</td>
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| 551-0313-00L  | Microbiology (Part I)                      | W    | 3    | 2V    | W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad |
| Abstract      | Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis. |
| Objective     | This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis. |
| Content       | Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis. |
| Lecture notes | Updated handouts will be provided during the class. |
| Literature    | Current literature references will be provided during the lectures. |
| Prerequisites / notice | English |
| The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture. |

| 551-0309-00L  | Concepts in Modern Genetics               | W    | 6    | 4V    | Y. Barral, D. Bopp, A. Hajnal, O. Voinnet |
| Abstract      | Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epi-genetics and RNA interference. |
| Objective     | This course focuses on the concepts of classical and modern genetics and genomics. |
| Content       | The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epi-genetics and RNA interference. |
| Lecture notes | Scripts and additional material will be provided during the semester. |

| Abstract      | Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, biostatistics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century. |
| Objective     | Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology. |
| Prerequisites / notice | Course participants have already acquired basic programming skills in UNIX, Python and R. Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN. |

Autumn Semester 2022
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key conceptual and theoretical areas.

4 credits

Analytical Competencies

To understand current research strategies in protein science.

Hours

Proteins have become an object of intense study in modern science, ranging from their use as therapeutics to elucidating their structure and function in the cell. Moreover, it is now possible to engineer and evolve tailor-made proteins, opening up many new areas of science. This course will attempt to cover the frontiers and remaining challenges, emphasizing the biochemical foundations of the various approaches.

Content

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes

No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature

Mainly based on original literature, a detailed list will be distributed during the lecture

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Social Competencies

Communication

Cooperation and Teamwork

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

529-0731-00L Nucleic Acids and Carbohydrates

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and Carbohydrates (autumn semester) or 529-0732-00 Proteins and Lipids (spring semester) can be counted for the Bachelor's degree.

W 6 credits 3G K. Lang, P. A. Kast, S. J. Sturla, H. Wennemers

Abstract

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content

Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes

No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature

Mainly based on original literature, a detailed list will be distributed during the lecture

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Problem-solving

Social Competencies

Communication

Cooperation and Teamwork

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Elective Compulsory Master Courses

Number Title Type ECTS Hours Lecturers

551-1401-00L Advanced Protein Engineering (University of Zurich) W 2 credits 2G University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BCH420

Restricted to max. 10 students from ETH

Abstract

Introduction into current research strategies in protein science.

Objective

To understand current research strategies in protein science.

Content

Proteins have become an object of intense study in modern science, ranging from their use as therapeutics to elucidating their structure and function in the cell. Moreover, it is now possible to engineer and evolve tailor-made proteins, opening up many new areas of science. This course will attempt to cover the frontiers and remaining challenges, emphasizing the biochemical foundations of the various approaches.

Lecture notes

Slides and references will be available on OLAT server.

https://www.olat.uzh.ch/olat/auth/repo/go?rid=600670219

Literature

PDFs will be available on OLAT server.

https://www.olat.uzh.ch/olat/auth/repo/go?rid=600670219

Prerequisites / notice

Solid knowledge in biochemistry strongly recommended

551-1153-00L Systems Biology of Metabolism W 4 credits 2V U. Sauer, N. Zamboni, M. Zampieri

Number of participants limited to 15.

Abstract

Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective

Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content

The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes

Script and original publications will be supplied during the course.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 342 of 2416
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

**Prerequisites / notice**
The course extends many of the generally introduced concepts and methods of the Concept Course in Systems Biology. It requires a good knowledge of biochemistry and basics of mathematics and chemistry.

**529-0004-01L Classical Simulation of (Bio)Molecular Systems**

**W 6 credits 4G**
P. H. Hübener, J. Dolenc, S. Riniker

**Abstract**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Objective**
Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

**Content**
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

**Lecture notes**
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

**Literature**
See: www.csms.ethz.ch/education/CSBMS

**Prerequisites / notice**
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

**401-0649-00L Applied Statistical Regression**

**W 5 credits 2V+1U**
M. Dettling

**Abstract**
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

**Lecture notes**
A script will be available.

**Literature**
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

**Fostered competencies**
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

**401-6215-00L Using R for Data Analysis and Graphics (Part I)**

**W 1.5 credits 1G**
M. Mächler

**Abstract**
The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

**Objective**
The students will be able to use the software R for simple data analysis and graphics.
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
The course resources will be provided via the Moodle web learning platform.

https://moodle-app2.let.ethz.ch/course/view.php?id=18279

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<tr>
<th>529-0041-00L</th>
<th>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</th>
<th>W</th>
<th>6 credits</th>
<th>3G</th>
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<tr>
<td>R. Zenobi, B. Hattendorf, P. Sinůes Martínez-Lozano</td>
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Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging.

Content
Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Lecture notes
Lecture notes will be made available online.

Literature
Information about relevant literature will be available in the lecture & in the lecture notes.

Prerequisites / notice
Exercises are an integral part of the lecture.

Prerequisites:
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)" (or equivalent)

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<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<td>Self-direction and Self-management</td>
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<table>
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<tr>
<th>551-1407-00L</th>
<th>RNA Biology Lecture Series I: Transcription &amp; Processing &amp; Translation</th>
<th>W</th>
<th>4 credits</th>
<th>2V</th>
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<tr>
<td>F. Allain, N. Ban, S. Jonas, U. Kutay, further lecturers</td>
<td></td>
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</table>

Abstract
This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Objective
The students should obtain an understanding of these processes, which are at work during gene expression.

Content
Transcription & 3’end formation: splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP biogenesis & nuclear export, mRNA surveillance & mRNA turnover; signal transduction & RNA.

Prerequisites / notice
Basic knowledge of cell and molecular biology.

<table>
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<tr>
<th>551-1409-00L</th>
<th>RNA Biology Lecture Series II: Non-Coding RNAs:</th>
<th>W</th>
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<tr>
<td>J. Hall, M. Stoffel, further lecturers</td>
<td></td>
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</tr>
</tbody>
</table>

Abstract
This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.
Analytical Competencies

Adaptability and Flexibility

Concepts and Theories

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Lecture notes

Theory and corresponding exercises are merged together during the classes.

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

Methods to endow proteins with novel functionalities.

Subject-specific Competencies

- Concepts and Theories
  - assessed
- Techniques and Technologies
  - not assessed

Method-specific Competencies

- Analytical Competencies
  - assessed
- Decision-making
  - assessed
- Media and Digital Technologies
  - not assessed
- Problem-solving
  - assessed
- Project Management
  - assessed

Social Competencies

- Communication
  - not assessed
- Cooperation and Teamwork
  - not assessed
- Customer Orientation
  - not assessed
- Leadership and Responsibility
  - not assessed
- Self-presentation and Social Influence
  - not assessed
- Sensitivity to Diversity
  - assessed
- Negotiation
  - not assessed

Personal Competencies

- Adaptability and Flexibility
  - assessed
- Creative Thinking
  - assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - assessed
- Self-awareness and Self-reflection
  - assessed
- Self-direction and Self-management
  - assessed

Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context. B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro. C) Critically analyze and assess current chemical biology articles. D) Question the approaches learned and apply them to new biological problems.
principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries);
principles of genetic code expansion (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing);
chemical biology of ubiquitin and targeted protein degradation.

4G

Type
Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic

Not assessed

Concepts and Theories
Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

See: www.csms.ethz.ch/education/CSBMS

Communication
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic

Assessed

Assessed

Assessed

Notes

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts
downloadable from the Moodle server).

Lecture notes

Not assessed

Not assessed

Not assessed

Note for BSc Biology students: Only one of the two
course concepts 529-0731-00 Nucleic Acids and
Carbohydrates (autumn semester) or 529-0732-00
Proteins and Lipids (spring semester) can be counted for
the Bachelor's degree.

Note

Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Fostered

Subject-specific Competencies
Concepts and Theories
Assessed
Techniques and Technologies
Assessed

Method-specific Competencies
Analytical Competencies
Assessed
Decision-making
Not assessed
Media and Digital Technologies
Not assessed
Problem-solving
Assessed
Project Management
Not assessed

Social Competencies
Communication
Not assessed
Cooperation and Teamwork
Not assessed
Customer Orientation
Not assessed
Leadership and Responsibility
Not assessed
Self-presentation and Social Influence
Not assessed
Sensitivity to Diversity
Not assessed
Negotiation
Not assessed

Personal Competencies
Adaptability and Flexibility
Not assessed
Creative Thinking
Assessed
Critical Thinking
Assessed
Integrity and Work Ethics
Not assessed
Self-awareness and Self-reflection
Not assessed
Self-direction and Self-management
Not assessed

Autumn Semester 2022

Elective Major: Biological Chemistry

Elective Compulsory Concept Courses

Number
529-0731-00L

Title
Nucleic Acids and Carbohydrates

Type
W

ECTS
6 credits

Hours
3G

Lecturers
K. Lang, P. A. Kast, S. J. Sturla, H. Wennemers

Abstract
Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and
PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and
repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective
Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and
PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and
repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content
Structure, function and chemistry of nucleic acids and carbohydrates, DNA/RNA structure and synthesis; recombinant DNA technology and
PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and
repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Literature
Mainly based on original literature, a detailed list will be distributed during the lecture

Lecture notes

No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts
downloadable from the Moodle server).

Fostered

Subject-specific Competencies
Concepts and Theories
Assessed
Techniques and Technologies
Assessed

Method-specific Competencies
Analytical Competencies
Assessed
Problem-solving
Assessed

Social Competencies
Communication
Assessed
Cooperation and Teamwork
Assessed

Personal Competencies
Self-awareness and Self-reflection
Assessed
Self-direction and Self-management
Assessed

Elective Compulsory Master Courses

Number
529-0004-01L

Title
Classical Simulation of (Bio)Molecular Systems

Type
W

ECTS
6 credits

Hours
4G

Lecturers
P. H. Hünenberger, J. Dolenc, S. Riniker

Abstract
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic
interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective
Introduction to classical (atomicistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic
interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Literature
See: www.csms.ethz.ch/education/CSBMS

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 346 of 2416
529-0233-01L Organic Synthesis: Methods and Strategies

Abstract
The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

Objective
Extension and deepening of the knowledge in organic synthesis and the principles of structure and reactivity.

Content

Literature

Prerequisites
OC I-IV

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

529-0243-01L Transition Metal Catalysis: From Mechanisms to Applications

Abstract
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint

Objective
Understanding and critical evaluation of current research in transition metal catalysis. Design of mechanistic experiments to elucidate reaction mechanisms. Synthetic relevance of transition metal catalysis. Students will also learn about writing an original research proposal during a workshop.

Content
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint. Synthetic applications of these reactions. Introduction and application of tools for the elucidation of mechanisms. Selected examples of topics include: C-H activation, C-O activation, C-C activation, redox active ligands, main group redox catalysis, bimetallic catalysis.

Prerequisites

- Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACIII

Fostered competencies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

529-0040-00L Modern Mass Spectrometry, Hyphenated Methods,
and Chemometrics

Abstract
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Prerequisites

- Analytical Chemistry I (3. Semester)
- Analytical Chemistry II (4. Semester)

Fostered competencies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
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Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 347 of 2416
The students should obtain an understanding of these processes, which are at work during gene expression.

This course covers aspects of RNA biology related to the functions of non-coding RNAs as well as their use as drugs to treat diseases.

3G

Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.

Citations from the original literature relevant to the individual lectures will be assigned weekly.

M. Fussenegger

529-0240-00L

Chemical Biology - Peptides

W

6 credits

3G

H. Wennemers

Abstract

An advanced course on the synthesis, properties and function of peptides in chemistry and biology.

Objective

Knowledge of the synthesis, properties and function of peptides in chemistry and biology.

Content

Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.

Lecture notes

Citations from the original literature relevant to the individual lectures will be assigned weekly.

Literature


636-0108-00L

Biological Engineering and Biotechnology

W

4 credits

3V

M. Fussenegger

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Lecture notes

Handout during the course.

Prerequisites / notice

Basic knowledge of cell and molecular biology.

551-1407-00L

RNA Biology Lecture Series I: Transcription & Processing & Translation

W

4 credits

2V

F. Allain, N. Ban, S. Jonas, U. Kutay, further lecturers

Abstract

This course covers aspects of RNA biology related to gene expression at the posttranscriptional level. These include RNA transcription, processing, alternative splicing, editing, export and translation.

Objective

The students should obtain an understanding of these processes, which are at work during gene expression.

Content

Transcription & 3’d end formation; splicing, alternative splicing, RNA editing; the ribosome & translation, translation regulation, RNP biogenesis & nuclear export, miRNA surveillance & miRNA turnover; signal transduction & RNA.

551-1409-00L

RNA Biology Lecture Series II: Non-Coding RNAs: Biology and Therapeutics

W

4 credits

2V

J. Hall, M. Stoffel, further lecturers

Abstract

Does not take place this semester.

Objective

The students should get familiar with the wide array of roles, which non-coding RNAs play in cellular functions.

Content

Micro RNAs; computational approaches to miRNAs; micro RNA function in metabolism; viruses and viral RNAs; nucleic acid-based drugs; ncRNA-mediated genome regulation; epigenetic programmes of genome remodelling in ciliates; telomerase and telomeres; rRNA biology.

Prerequisites / notice

Basic knowledge of cell and molecular biology.

529-0241-10L

Selectivity in Organic Synthesis

W

6 credits

3G

J. W. Bode

Abstract

Fundamentals of selective organic reactions, including current and historical examples of enantioselectivity, regioselectivity, chemoselectivity. Further aspects include recent developments in catalysis, strategies and tools for selective organic synthesis.

Objective

Understanding and explaining the origin of selectivity in organic synthesis and the application of selective organic reactions to the construction of complex organic and biological molecules.

Content

Fundamental concepts and recent advances for the selective synthesis of complex organic molecules, including natural products, pharmaceuticals, and biological molecules. Key concepts include the development of enantioselective and regioselective catalysts, the identification of new reaction mechanisms and pathways, and technological advances for facilitating the synthesis of organic molecules. Analysis of key primarily literature including identification of trends, key precendents, and emerging topics will be emphasized.

Lecture notes

will be provided in class and online

Literature

Suggesting Textbooks

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

• Basics of theory of probability
• Boltzmann’s law
• Entropy maximization and Gibbs free energy minimization
• Ligand-receptor: two-state systems and the MWC model
• Random walks, diffusion, crowding
• Electrostatics for salty solutions
• Elasticity: fibers and membranes
• Molecular motors
• Action potential: Hodgkin-Huxley model
• Photosynthesis and vision
• Gene regulation
• Development: Turing patterns
• Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o’clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!


Participants need a good command of
• differentiation and integration of a function with one or more variables (basics of Analysis),
• Newton’s and Coulomb’s laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.
Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

551-0357-00L Cellular Matters: From Milestones to Open Questions

W 4 credits 2S

Abstract
In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Objective
In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

Content
In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverers on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer's, Parkinson's, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Lecture notes
The presentations will be made available after the lectures.

Literature
The milestone papers will be provided in advance.

The first lecture will serve to form groups of students and assign papers.
Abstract
Overview of modern chemical biology and synthetic biochemistry techniques, focused on protein modification and labeling and on methods to endow proteins with novel functionalities.

Objective
After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

Content
- Principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries);
- Principles of genetic code expansion (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing):
- Chemical biology of ubiquitin and targeted protein degradation

Lecture notes
A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature
Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice
Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Elective Concept Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>551-0307-00L</td>
<td>Molecular and Structural Biology I: Protein Structure and Function</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Glockshuber, K. Locher, E. Weber-Ban</td>
</tr>
</tbody>
</table>

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Bibliography:
- Creighton, T.E., Proteins, Freeman, (1993)
- Ferretti, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.
Cellular Biochemistry (Part I)

**Abstract**

Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Prerequisites / notice**

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Lecture notes**

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

**Literature**

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- **Social Competencies**
  - Communication
  - Cooperation and Teamwork

- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

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Bioinformatics

**Abstract**

Students will study bioinformatic concepts in the areas of genomics, metagenomics, proteomics, biological networks, bioinformatics and bioethics. Through integrated lectures, practical hands-on sessions and homework assignments, students will also be trained in analytical and programming skills to meet the emerging increase in data-driven knowledge generation in biology in the 21st century.

**Objective**

Students will have an advanced understanding of the underlying concepts behind modern bioinformatic analyses at genome, metagenome and proteome-wide scales. They will be familiar with the most common data types, where to access them, and how to analytically work with them to address contemporary questions in the field of biology.

**Prerequisites / notice**

Course participants have already acquired basic programming skills in UNIX, Python and R.

**Lecture notes**

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- **Social Competencies**
  - Communication
  - Cooperation and Teamwork

- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

---

Concepts in Modern Genetics

**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics. The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Content**

Enrolment to this course unit only possible at ETH. No enrolment to module BIO548 at UZH.

**Lecture notes**

Scripts and additional material will be provided during the semester.

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Microbiology (Part I)

**Abstract**

Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Objective**

This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Content**

Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Lecture notes**

Updated handouts will be provided during the class.

**Literature**

Course participants have already acquired basic programming skills in UNIX, Python and R.

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- **Social Competencies**
  - Communication
  - Cooperation and Teamwork

- **Personal Competencies**
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

---

Bioinformatics

**Abstract**

Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes. Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Prerequisites / notice**

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Lecture notes**

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

**Literature**

Students bring their own computer with keyboard, internet access (browser) and software to connect to the ETH network via VPN.

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- **Social Competencies**
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- **Personal Competencies**
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  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

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Concepts in Modern Genetics

**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics. The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Content**

Enrolment to this course unit only possible at ETH. No enrolment to module BIO548 at UZH.

**Lecture notes**

Scripts and additional material will be provided during the semester.

**Recommended Elective Courses (for all Master Majors)**
I. Introduction to Moral Reasoning

1. Ethics - the basics
1.1 What ethics is not... 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity

1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

- Research Projects (for all Master Majors)

Research projects neither accepted nor registered nor approved will not be credited.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
551-1801-00L | Research Project I | O | 15 credits | 34A | Lecturers
Abstract

Research projects, with themes from the chosen scientific fields of interest, are intended to familiarise candidates with scientific procedures and operational methodologies through supervised participation in current research work.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>Research Project II ♦</td>
<td>O</td>
<td>15 credits</td>
<td>34A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

**Science in Perspective**

- see Science in Perspective: Type A: Enhancement of Reflection Capability
- Recommended Science in Perspective (Type B) for D-BIOL
- see Science in Perspective: Language Courses ETH/UZH

**Master's Thesis**

A Master's thesis neither accepted nor registered nor approved will not be credited.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract

The Master's research will be carried out on a theme in the chosen subject area and must be completed with a written report (Thesis) within six months.

**Master's Examination**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-1800-01L</td>
<td>Master's Examination ♦</td>
<td>O</td>
<td>4 credits</td>
<td>Lecturers</td>
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</table>

Abstract

In the Master's examination a student must provide proof of general knowledge in the elective major field. Starting with a discussion based on the Master's thesis further experiments and experimental strategies should be discussed in order to test the general understanding.

**Biology Master - Key for Type**

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<th>Key</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<th>Key</th>
<th>Type</th>
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<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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**Key for Hours**

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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<th>Type</th>
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<tbody>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards microsystems.

**Objective**

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

**Content**

Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

The lecture will be taught in English.

**Prerequisites / notice**

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

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**Course Format:**

- Lectures and Mini-Review presentations: Thursday 10-13
- Homework: Mini-Review
  (compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

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**Microsystems I: Process Technology and Integration**

**Abstract**

Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).

**Objective**

Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystems devices by the combination of unit process steps (→ process flow).

**Content**

- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific Microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.
- Application of selected technologies will be demonstrated on case studies.

**Lecture notes**

Handouts (available online)
227-0105-00L  Introduction to Estimation and Machine Learning  W  6 credits  4G  H. A. Loeliger

Abstract  Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

Objective  Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Content  Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more

Lecture notes  Lecture notes will be handed out as the course progresses.

Prerequisites / notice  solid basics in linear algebra and probability theory

227-0311-00L  Qubits, Electrons, Photons  W  6 credits  3V+2U  T. Zambelli

Abstract  In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective  Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).

Content  • Lagrangian and Hamiltonian: Symmetries and Poisson Brackets  
• Postulates of QM: Hilbert Spaces and Operators  
• Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator  
• Density Operator  
• Spin: Qubits, Bloch Equations, and NMR  
• Entanglement  
• Symmetries and Corresponding Operators  
• Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands  
• Harmonic Oscillator: Creation and Annihilation Operators  
• Identical Particles: Bosons and Fermions  
• Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER  
• Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes  No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

• M. Le Bellac, "Quantum Physics", 2011, Cambridge University Press  

Supplementary material will be uploaded in Moodle.

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+ (as rigorous and profound presentation of the mathematical framework) G. Dell'Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer

+ (as account of those formidable years) G. Gamow, "Thirty Years that Shook Physics", 1985, Dover Publications Inc.

Prerequisites / notice  The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II".

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
### 227-0385-10L Biomedical Imaging

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
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<td>Customer Orientation</td>
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</table>

#### Abstract

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

#### Objective

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

#### Content

- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PECT)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

#### Literature

Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

#### Prerequisites / notice

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

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### 227-0386-00L Biomedical Engineering

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Decision-making</td>
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#### Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

#### Objective

- Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology.
- Overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations.
- Also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.
- Most recent achievements and trends of the field of biomedical engineering are also outlined.
Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.

Lecture notes

Introduction to Biomedical Engineering
by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice

No specific requirements, BUT
IMET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while
HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Fostered competencies

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<td>Problem-solving</td>
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<td>Project Management</td>
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</table>

Social Competencies

| Communication                  | Not assessed |
| Cooperation and Teamwork       | Not assessed |
| Customer Orientation           | Not assessed |
| Leadership and Responsibility  | Not assessed |
| Self-presentation and Social Influence | Not assessed |
| Sensitivity to Diversity       | Not assessed |
| Negotiation                    | Not assessed |

Personal Competencies

| Adaptability and Flexibility   | Not assessed |
| Creative Thinking              | Not assessed |
| Critical Thinking              | Not assessed |
| Integrity and Work Ethics      | Not assessed |
| Self-awareness and Self-reflection | Not assessed |
| Self-direction and Self-management | Not assessed |

227-0393-10L Bioelectronics and Biosensors W 6 credits 2V+2U J. Vörös, M. F. Yañik

Abstract

The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective

During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content

Lecture topics:

1. Introduction
2. Sources of bioelectronic signals
3. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
5. Measuring bioelectronic signals
6. Detection and Noise
7. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
8. Measuring potentials in solution and core conductance model
9. Measuring mechanical signals with bioelectronics
10. In vivo stimulation and recording
11. Functional electric stimulation
12. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
14. Measuring biochemical signals

Lecture notes

A detailed script is provided to each lecture including the exercises and their solutions.

Literature

Plošney and Barr, Bioelectrics: A Quantitative Approach (Third edition)

Prerequisites / notice

The course requires an open attitude to the interdisciplinary approach of bioelectronics.

In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g., simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

The lecture slides will be provided as a PDF after each lecture.

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transmission and the generation of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Ahmed</td>
</tr>
</tbody>
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Note: The previous course title until HS21 "Microscale Acoustofluiddics"
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

**Content**

Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobotics to surface acoustic wave devices.

**Literature**


This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Prerequisites / notice**

Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

### 151-0601-00L Theory of Robotics and Mechatronics

**Abstract**

This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**

Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**

Available.

**Literature**


**Prerequisites / notice**

On site presence during (most) of the lectures highly encouraged!

**Fostered competencies**

- Self-direction and Self-management
- Problem-solving
- Decision-making
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Project Management
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creativity
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### 151-0905-00L Medical Technology Innovation - From Concept to Clinics

**Abstract**

Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

**Objective**

After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

**Lecture notes**

Available.

**Literature**

Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Prerequisites / notice**

On site presence during (most) of the lectures highly encouraged!

**Fostered competencies**

- Self-direction and Self-management
- Problem-solving
- Decision-making
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Project Management
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creativity
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### 151-0913-00L Introduction to Photonics

**Abstract**

This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.
Objective

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.

Content

I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics I, Physics II

227-1033-00L Neurornorphic Engineering I
W 6 credits 2V+3U T. Delbrück, G. Indiveri, S.-C. Liu

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH. Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.
Content

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

E. Konukoglu

None

This course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

227-1051-00L

Systems Neuroscience (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI415

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions.

Objective

To understand the basic concepts underlying perceptual, motor and cognitive functions.

Content

Main emphasis sensory systems, with complements on motor and cognitive functions.

Lecture notes


"Principles of Neural Science", Kandel, Schwartz, and Jessel

Prerequisites / notice

none

227-0166-00L

Analog Integrated Circuits

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Lecture notes

Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature


227-0447-00L

Image Analysis and Computer Vision

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Lecture notes

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

227-0468-00L

Analog Signal Processing and Filtering

Suitable for Master Students as well as Doctoral Students.

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductorulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

The graph methods are also supported with teaching videos: https://tube.switch.ch/Channels/d206c96?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites:

- Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

- Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria …) and of the main properties of linear systems is necessary.

227-0621-00L

**Objective**

Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Students learn and compare these future memory technologies by means of interactive lectures, group projects, and laboratory sessions. The course employs constructive alignment and active learning teaching concepts.

**Content**

Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict them at least niche applications for ever-growing hardware market. However, some of technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now.

Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other's. Principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others, and different memory technologies make up the course content. The goal of the course is to present selected memory technology in form of 3 presentations (20-25 min each), followed the exam example given by the lecturer.

**Literature**

Lecture notes will be made available on the website.
Objective

The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since such differences become the most evident during actual collaborative work, the course is based on a current project in physiology research that combines medicine and engineering. For the engineering students, the specific aims of the course are to:

- Acquire a working understanding of the anatomy and physiology of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the found solutions to a cross-disciplinary audience.

Content

After a general introduction to interdisciplinary communication and detailed background on the collaborative project, the engineering students will team up with medical students to find solutions to a biomedical challenge. In the process, they will be supervised both by lecturers from ETH Zürich and the University of Zürich, receiving coaching customized to the project. The course will end with each team presenting their solution to a cross-disciplinary audience.

Lecture notes

Handouts and relevant literature will be provided.

Prerequisites / notice

IMPORTANT: Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.

Fostered competencies

Method-specific Competencies
- Analytical Competencies assessed
  - Problem-solving assessed
  - Project Management assessed
Social Competencies
- Communication assessed
  - Cooperation and Teamwork assessed
  - Customer Orientation assessed

227-0939-00L Cell Biophysics W 6 credits 4G T. Zambelli

Abstract

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.

Objective

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann’s law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton’s and Coulomb’s laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.
This seminar deals with the development of clinically relevant computational tools and/or their application to psychiatry and psychosomatics. It is complementary to the annual Computational Psychiatry Course and serves to build bridges between computational scientists and clinicians. It is designed to foster in-depth exchange, with ample time for discussion.

Participants are expected to be familiar with general principles of statistics (including Bayesian statistics) and have successfully completed the course “Computational Psychiatry” (Course number 227-0971-00L).

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/special-students-university-of-zurich.html

Information for UZH students: Enrolment to this course unit only possible at ETH Zurich. No enrolment to module BMT20002.

No enrolment to module BMT20002.

Number of participants limited to 24.

Number of participants limited to 320.

Number of participants limited to 24.

Number of participants limited to 320.

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Does not take place this semester.

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Does not take place this semester.

Number of participants limited to 24.
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will cover advanced topics in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills. The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

The objective of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

The abstract covers advanced topics in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.

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Abstract

This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Objective

Objective 1:
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2:
Acquire skills to design novel non-invasive technologies for sport and health.

Content

The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

376-1219-00L Rehabilitation Engng II: Rehabilitation of Sensory and Vegetative Functions

Abstract

Rehabilitation Engng II is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective

Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

Content

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation of use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g., BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Autumn Semester 2022
Literature

Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice

Target Group:
Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Autumn Semester 2022
Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

<table>
<thead>
<tr>
<th>Number of participants limited to 25.</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomicrofluidic Engineering</td>
<td>W 6 credits 3G A. de Mello</td>
</tr>
<tr>
<td>Abstract</td>
<td>Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.</td>
</tr>
<tr>
<td>Objective</td>
<td>We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.</td>
</tr>
<tr>
<td>Content</td>
<td>Specific topics covered in the course include, but are not limited to:</td>
</tr>
<tr>
<td></td>
<td>1. Theoretical Concepts</td>
</tr>
<tr>
<td></td>
<td>Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.</td>
</tr>
<tr>
<td></td>
<td>2. Microfluidic Device Manufacture</td>
</tr>
<tr>
<td></td>
<td>Basic principles of conventional lithography of rigid materials, 'soft' lithography, polymer machining (injection molding, hot embossing, and 3D-printing).</td>
</tr>
<tr>
<td></td>
<td>3. Electrokinetics</td>
</tr>
<tr>
<td></td>
<td>Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.</td>
</tr>
<tr>
<td></td>
<td>4. Mass Transfer Phenomena</td>
</tr>
<tr>
<td></td>
<td>Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Pécel number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.</td>
</tr>
<tr>
<td></td>
<td>5. Heat Transfer Phenomena</td>
</tr>
<tr>
<td></td>
<td>Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.</td>
</tr>
<tr>
<td></td>
<td>6. Microfluidic Systems for Materials Synthesis</td>
</tr>
<tr>
<td></td>
<td>Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery &amp; characterization.</td>
</tr>
<tr>
<td></td>
<td>7. Point-of-Care Diagnostics</td>
</tr>
<tr>
<td></td>
<td>Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.</td>
</tr>
<tr>
<td></td>
<td>8. Microscale DNA Amplification</td>
</tr>
<tr>
<td></td>
<td>Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.</td>
</tr>
<tr>
<td></td>
<td>9. Small Volume Molecular Detection</td>
</tr>
<tr>
<td></td>
<td>Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.</td>
</tr>
<tr>
<td></td>
<td>10. Droplets and Segmented Flows</td>
</tr>
<tr>
<td></td>
<td>Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.</td>
</tr>
<tr>
<td></td>
<td>11. Single Cell Analysis</td>
</tr>
<tr>
<td></td>
<td>Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.</td>
</tr>
<tr>
<td></td>
<td>Lecture handouts; background literature, problem sheets and notes will be provided electronically through the course Moodle site.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
</tr>
<tr>
<td></td>
<td>There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.</td>
</tr>
</tbody>
</table>
Students will be assessed.

The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- Social Competencies
  - Communication
  - Cooperation and Teamwork

- Personal Competencies
  - Adaptability and Flexibility
  - Critical Thinking

Lecture notes

Handout during the course.

### Biology Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3D animation database/software to use ‘anatomical language’ to retrieve anatomical structures to understand basic medical terminology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>- The Human Body: nomenclature, orientations, tissues - Musculoskeletal system, Muscle contraction - Blood vessels, Heart, Circulation - Blood, Immune system - Respiratory system - Acid-Base-Homeostasis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture notes and handouts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 227-0945-00L    | Cell and Molecular Biology for Engineers I | W    | 3    | 2G    | to be announced |
| Abstract        | The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology. |
| Objective       | After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested. |
| Content         | Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells. In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade. |

Lecture notes

Scripts of all lectures will be available.
Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Social Competencies

| Communication | not assessed |
| Cooperation and Teamwork | assessed |
| Customer Orientation | not assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity | not assessed |
| Negotiation | not assessed |

Personal Competencies

| Adaptability and Flexibility | assessed |
| Creative Thinking | assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | not assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and Self-management | not assessed |

227-0949-00L Biological Methods for Engineers (Basic Lab) W 3 credits 5P C. Frei
Number of participants limited to 10.

Abstract
The course during 7 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Content
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Prerequisites / notice
Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Social Competencies

| Cooperation and Teamwork | assessed |
| Customer Orientation | not assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity | not assessed |
| Negotiation | not assessed |

Personal Competencies

| Adaptability and Flexibility | not assessed |
| Creative Thinking | assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and Self-management | not assessed |

Bioimaging

Track Core Courses

During the Master programme, a minimum of 12 CP must be obtained from track core courses.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüßmann</td>
</tr>
</tbody>
</table>

Abstract
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective
Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications
### Content

- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

### Lecture notes

Lecture notes and handouts

### Literature

Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

### Prerequisites / notice

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

### Fostered competencies

<table>
<thead>
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<tbody>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### 227-0386-00L Biomedical Engineering

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

### Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

### Content

- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

### Lecture notes

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

moodle page of the course

### Prerequisites / notice

No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**227-0447-00L** Image Analysis and Computer Vision

**Title** Image Analysis and Computer Vision

**W** 6 credits

**3V+1U**

**E. Konukoglu, F. Yu**


**Objective** This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Content**

**Lecture notes** Course material Script, computer demonstrations, exercises and problem solutions

**Prerequisites**

**notice** Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

**Lecture notes**

**Prerequisites:**

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

**Literature**

Available online

---

**Recommended Elective Courses**

These courses are particularly recommended for the Bioimaging track. Please consult your track advisor if you wish to select other subjects.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0311-00L</td>
<td>Qubits, Electrons, Photons</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>T. Zambelli</td>
</tr>
</tbody>
</table>

**Abstract**

In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

**Objective**

Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER. quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

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Data: 01.11.2022 12:41

Autumn Semester 2022

Page 374 of 2416
Content
• Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
• Postulates of QM: Hilbert Spaces and Operators
• Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
• Density Operator
• Spin: Qubits, Bloch Equations, and NMR
• Entanglement
• Symmetries and Corresponding Operators
• Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
• Harmonic Oscillator: Creation and Annihilation Operators
• Identical Particles: Bosons and Fermions
• Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
• Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature

Supplementary material will be uploaded in Moodle.

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+ (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer
+ (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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</tr>
</thead>
<tbody>
<tr>
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<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
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<td>Customer Orientation</td>
<td>not assessed</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tr>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

227-0421-00L Deep Learning in Artificial and Biological Neuronal Networks

W 4 credits 3G B. Grewe

Abstract
Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 375 of 2416
Content

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the marmoset neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans, in general, ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g., recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

Abstract

This seminar teaches problem solving skills for computational neuroimaging, based on joint analyses of neuroimaging and behavioral data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g., mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

Objective

2. Acquisition of practical problem solving strategies for computational modeling of neuroimaging data.

Content

This seminar teaches problem solving skills for computational neuroimaging, based on joint analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g., mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.

Prerequisites / notice

The participants are expected to have successfully completed at least one of the following courses: ‘Methods & models for fMRI data analysis’, ‘Translational Neuromodeling’, ‘Computational Psychiatry’
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties

2V+1U+1A

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After

A. Stemmer

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed

Introduction to Neuroinformatics

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on

physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinae and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, conductanceamplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Abstract

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the interconnections of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Objective

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simple models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

Abstract

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content

The module begins with an introduction to the fundamental equations describing the effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

Content

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.

Objective

Familiarize students with basic science and engineering principles governing the nano domain.

Content

The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures.
Literature


Prerequisites / notice

Lectures and Mini-Review presentations: Thursday 10-13

Homework: Mini-Review

(compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

252-0543-01L

Computer Graphics

W 8 credits

Objective

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

Content

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

Lecture notes

no

Literature

Books:
- High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
- Multiple view geometry in computer vision
- Physically Based Rendering: From Theory to Implementation

Prerequisites / notice

Prerequisites:
- Fundamentals of calculus and linear algebra
- basic concepts of algorithms and data structures, programming skills in C/C++, Visual Computing course recommended.

The programming assignments will be in C++. This will not be taught in the class.

402-0674-00L

Physics in Medical Research: From Atoms to Cells

W 6 credits

Objective

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

Content

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and electron diffraction. Both effects are perfectly described by the kinematic theory.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

465-0953-00L

Biostatistics

W 4 credits

Objective

The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.

- know the commonly used methods in biostatistics
- perform simple data analysis with R

227-0976-00L

Computational Psychiatry & Computational Psychosomatics

W 2 credits

Remark

Does not take place this semester.
Number of participants limited to 24.

Information for UZH students:
Enrolment to this course unit only possible at ETH Zurich.
No enrolment to module BMT20002.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html

Abstract
This seminar deals with the development of clinically relevant computational tools and/or their application to psychiatry and psychosomatics. It is complementary to the annual Computational Psychiatry Course and serves to build bridges between computational scientists and clinicians. It is designed to foster in-depth exchange, with ample time for discussion.

Objective
Understanding strengths and weaknesses of current trends in the development of clinically relevant computational tools and their application to problems in psychiatry and psychosomatics.

Content
This seminar deals with the development of computational tools (e.g. generative models, machine learning) and/or their application to psychiatry and psychosomatics. The seminar includes (i) presentations by computational scientists and clinicians, (ii) group discussion with focus on methodology and clinical utility, (iii) self-study based on literature provided by presenters.

Literature
Literature for additional self-study of the topics presented in this seminar will be provided by the presenters and will be available online at https://www.tnu.ethz.ch/en/teaching

Prerequisites / notice
Participants are expected to be familiar with general principles of statistics (including Bayesian statistics) and have successfully completed the course “Computational Psychiatry” (Course number 227-0971-00L).

Biology Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
</tbody>
</table>

Abstract
Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to use 'anatomical language' to retrieve anatomical structures to understand basic medical terminology

Objective
To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

Content
- The Human Body: nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

Lecture notes
Lecture notes and handouts

Literature
Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008
Faller A., Schuenke M. The Human Body; Thieme 2004
Netter F. Atlas of human anatomy; Elsevier 2014

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>to be announced</td>
</tr>
</tbody>
</table>

Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes
Scripts of all lectures will be available.

Literature
Biological Methods for Engineers (Basic Lab)  
Number of participants limited to 10.

Abstract
The course during 7 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Content

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Adaptability and Flexibility</td>
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<tr>
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<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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</tbody>
</table>

| Analytical Competencies      | Decision-making              | Media and Digital Technologies | not assessed |
| Problemsolving               |                              | Problem-solving              | assessed |
| Project Management           |                              |                               |                     |
| Social Competencies          |                              |                               |                     |
| Communication                |                              |                               |                     |
| Cooperation and Teamwork     |                              |                               |                     |
| Customer Orientation         |                              |                               |                     |
| Leadership and Responsibility|                              |                               |                     |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity     |                              |                               |                     |
| Negotiation                  |                              |                               |                     |
| Social Competencies          |                              |                               |                     |
| Communication                |                              |                               |                     |
| Cooperation and Teamwork     |                              |                               |                     |
| Customer Orientation         |                              |                               |                     |
| Leadership and Responsibility|                              |                               |                     |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity     |                              |                               |                     |
| Negotiation                  |                              |                               |                     |
| Social Competencies          |                              |                               |                     |
| Communication                |                              |                               |                     |
| Cooperation and Teamwork     |                              |                               |                     |
| Customer Orientation         |                              |                               |                     |
| Leadership and Responsibility|                              |                               |                     |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity     |                              |                               |                     |
| Negotiation                  |                              |                               |                     |
| Social Competencies          |                              |                               |                     |
| Communication                |                              |                               |                     |
| Cooperation and Teamwork     |                              |                               |                     |
| Customer Orientation         |                              |                               |                     |
| Leadership and Responsibility|                              |                               |                     |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity     |                              |                               |                     |
| Negotiation                  |                              |                               |                     |
| Social Competencies          |                              |                               |                     |
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| Self-presentation and Social Influence | not assessed |
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| Customer Orientation         |                              |                               |                     |
| Leadership and Responsibility|                              |                               |                     |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity     |                              |                               |                     |
| Negotiation                  |                              |                               |                     |

Personal Competencies
Adaptability and Flexibility | not assessed |
Creative Thinking | assessed |
Critical Thinking | assessed |
Integrity and Work Ethics | assessed |
Self-awareness and Self-reflection | not assessed |
Self-direction and Self-management | not assessed |

Biomechanics

Track Core Courses
During the Master programme, a minimum of 12 CP must be obtained from track core courses.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>S. Kozerke, K. P. Prüssmann</td>
</tr>
</tbody>
</table>

Abstract
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective
Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications
Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.

Biomedical sensors both wearable and also biochemical sensors.

Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.

Bioinformatics: genomic and proteomic tools, databases and basic calculations.

Equations describing basic reactions and enzyme kinetics.

Medical optics: Optical components and systems used in hospitals.

Basic concepts of tissue engineering and organ printing.

Biomaterials and their medical applications.

Function of the heart and the circulatory system.

Transport and exchange of substances in the human body, compartment modeling.

The respiratory system.

Bioimaging.

Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes

Introduction to Biomedical Engineering

by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice

No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
### Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale

**Concepts and Theories**

- Techniques and Technologies (assessed)
- Analytical Competencies (assessed)
- Decision-making (assessed)
- Media and Digital Technologies (not assessed)
- Problem-solving (not assessed)
- Project Management (not assessed)

**Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials.**

The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The course includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course language is English.

### Content

**Lecture notes**

- Course material Script, computer demonstrations, exercises and problem solutions
- Prerequisites:

  - Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
  - The course language is English.

**Abstract**


**Objective**

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

### Subject-specific Competencies

<table>
<thead>
<tr>
<th>Competency</th>
<th>Observed</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<tr>
<td>Problem-solving</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>not assessed</td>
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<tr>
<td>Communication</td>
<td>not assessed</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td>Negotiation</td>
<td>not assessed</td>
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</tbody>
</table>

### Analytical Competencies

- Adaptable and Flexible (not assessed)
- Creative Thinking (not assessed)
- Critical Thinking (not assessed)
- Integrity and Work Ethics (not assessed)
- Self-awareness and Self-reflection (not assessed)
- Self-direction and Self-management (not assessed)

### Social Competencies

- Adaptability and Flexibility (not assessed)
- Critical Thinking (not assessed)
- Leadership and Responsibility (not assessed)
- Self-presentation and Social Influence (not assessed)
- Negotiation (not assessed)

### Personal Competencies

- Adaptability and Flexibility (not assessed)
- Creativity (not assessed)
- Critical Thinking (not assessed)
- Integrity and Work Ethics (not assessed)
- Self-awareness and Self-reflection (not assessed)
- Self-direction and Self-management (not assessed)

### Prerequisites / Notice

- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
- The course language is English.

### Literature

- Will be indicated during the lecture.

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**227-0447-00L**  
**Image Analysis and Computer Vision**  
**W** 6 credits  3V+1U  
**E. Konukoglu, F. Yu**

**Objective**

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

### Content

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

### Social Competencies

- Adaptability and Flexibility (not assessed)
- Critical Thinking (not assessed)
- Leadership and Responsibility (not assessed)
- Self-presentation and Social Influence (not assessed)
- Negotiation (not assessed)

### Personal Competencies

- Adaptability and Flexibility (not assessed)
- Critical Thinking (not assessed)
- Integrity and Work Ethics (not assessed)
- Self-awareness and Self-reflection (not assessed)
- Self-direction and Self-management (not assessed)

### Prerequisites / Notice

- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
- The course language is English.

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**227-0965-00L**  
**Micro and Nano-Tomography of Biological Tissues**  
**W** 4 credits  3G  
**M. Stamparoni, F. Marone Welford**

**Abstract**

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

**Objective**

An introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

**Content**

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

### Literature

Available online

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**376-0121-00L**  
**Multiscale Bone Biomechanics**  
**W** 6 credits  4S  
**R. Müller, X.-H. Qin**

**Objective**

The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

### Content

The learning objectives include:

1. advanced knowledge of the state-of-the-are in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-art multiscale simulation techniques;
5. improved programing skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

### Literature

Available online
Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis. To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions courses focused on QAlity and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A).

Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

Material will be provided on Moodle and eColab. Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0524-00L</td>
<td>Continuum Mechanics I</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>A. E. Ehret</td>
</tr>
</tbody>
</table>

Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.

Content
Theoretical models are complemented by examples of engineering applications and experiments.

Lecture notes
yes
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

### Lecture notes
Available.

### Literature

### Prerequisites / notice
The lecture will be taught in English.

### Prerequisites / notice
The lecture will be taught in English.

### Literature

### Prerequisites / notice
Lectures and Mini-Review presentations: Thursday 10-13
Homework: Mini-Review (compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.
This seminar covers advanced topics in digital humans including both seminal research papers as well as the latest research results. A collection of research papers is selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.

### Literature

Individual research papers are selected each term. See https://vlg.inf.ethz.ch/ and http://graphics.ethz.ch/ for example papers.

### Objective

This seminar covers advanced topics in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected. The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills. The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across disciplinary boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across disciplinary boundaries.

### Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

### Prerequisites / notice

On site presence during (most) of the lectures highly encouraged! Graded innovation project will require on-site presence.

### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

### Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### Personal Competencies

- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Prerequisites / notice

- Number of participants limited to 24.
- Number of participants limited to 60.
- Number of participants limited to 24.

### Objective

- Acquire skills to design novel non-invasive technologies for sport and health.
- Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.
Content

The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

W 3 credits 2V
R. Rienner, O. Lambercy

Abstract
Rehabilitation Engineering is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
- Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
- Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
- Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g., BrainPort)
- Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces
Biocompatible Materials

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Literature


Prerequisites / notice

Target Group:

- Students of higher semesters and PhD students of 
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich

Selected Journal Articles and Web Links:


VideoTact, ForeThought Development, LLC. http://my.execpc.com/?dwysocki/videotac.html

376-1714-00L Biocompatible Materials W 4 credits 3V K. Maniura, M. Rottmar, M. Zenobi-Wong

Abstract

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

Handouts are deposited online (moodle).
Mostly formal lectures (2×45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to Application of MATLAB in the Human Movement.

Students will acquire the ability to independently load, plot, and process kinematic, kinetic and electromyographical data using the MATLAB Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For Literature:

- Handouts will be made available.
- During the lecture, several electronically available MATLAB introductions are indicated. Course-specific scripts will be provided by the E. Delamarche B. Helgason W Physics in Medical Research: From Atoms to Cells

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patternening proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETH2/IBM Nanotech Center infrastructure if needed.

Content

- Mostly formal lectures (2×45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photospotting of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

402-0674-00L

Abstract

This course introduces the basic principles of trauma biomechanics and rehabilitation focussing on sports injuries. This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore more possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.

Content

- Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

- lecture notes

- Literature

- Prerequisites / notice

- A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.

376-1730-00L

Abstract

Students will learn to import, process and graphically present experimental data using the MATLAB computing environment. Both the data and the methods of analysis will be typical for experiments in Human Movement Science (i.e. kinematics, kinetics and electromyography). Students will acquire the ability to independently load, plot, and process kinematic, kinetic and electromyographical data using the MATLAB computing environment.

Content

- Drawbacks of Excel; Possibilities in MATLAB; Import of several data formats; Plot of one and more signals; Removing of an offset and filtering of data based on self-written functions; Normalisation and parametrisation of data; Reliability; Interpolation, Differentiation and Integration in MATLAB.

Literature

During the lecture, several electronically available MATLAB introductions are indicated. Course-specific scripts will be provided by the lecturer. A Laptop with MATLAB installed (v2009 or higher) and wireless internet access is mandatory. Two students can share a laptop if necessary. A MATLAB student version can be obtained at Stud-IDES for free.
Students will be able to retrieve anatomical structures to use anatomical language to describe basic physiological processes of the human body to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to understand basic medical terminology to perform simple data analysis with R.

<table>
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<tr>
<th>Number</th>
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<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Wyss</td>
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<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>to be announced</td>
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</tbody>
</table>

Does not take place this semester.

The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.

Objective
- to understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

Content
- The Human Body: nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

Lecture notes
Lecture notes and handouts

Literature
Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008
Faller A., Schuenke M. The Human Body; Thieme 2004
Netter F. Atlas of human anatomy; Elsevier 2014

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Biological Methods for Engineers (Basic Lab) □ 3 credits

Number of participants limited to 10.

Abstract
The course during 7 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Content

Prerequisites / notice
Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Medical Physics

Track Core Courses

During the Master programme, a minimum of 12 CP must be obtained from track core courses.

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
227-0311-00L | Qubits, Electrons, Photons | W | 6 credits | 3V+2U | T. Zambelli

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 390 of 2416
Content

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature


Supplementary material will be uploaded in Moodle.

Prerequisites / notice

+ (as rigorous and profound presentation of the mathematical framework) G. Dell'Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer

+ (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Fostered competencies

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td></td>
<td>Self-direction and Self-management</td>
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227-0385-10L Biomedical Imaging W 6 credits 5G S. Kozerke, K. P. Prüssmann

Abstract

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective

Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Content

- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

Lecture notes

Lecture notes and handouts

Literature

Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011
No text content extracted from the image.
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxido and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Symmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

227-0941-00L  
**Physics and Mathematics of Radiotherapy Planning**  
(University of Zurich)

This lecture will provide a detailed introduction to radiotherapy treatment planning. The course considers the physical interactions of radiation in tissue, the mathematical aspects of treatment planning and additional aspects of central importance for radiotherapy planning.

**Objective**

Students shall develop a thorough understanding of the foundations of radiotherapy from a physics and mathematics perspective, focusing on algorithmic components. After completing the course students should be able to implement the main components of a radiotherapy treatment planning system.

**Content**

Radiotherapy is one of the main treatment options against cancer. Today, more than 50% of cancer patients receive radiation as part of their treatment. Modern radiotherapy is a highly technology driven field.

Research and development in medical physics has improved the precision of radiotherapy substantially. Using intensity-modulated radiotherapy (IMRT), radiation can be delivered precisely to tumors while minimizing radiation exposure of healthy organs surrounding the tumor. Thereby, medical physics has provided radiation oncologists with new curative treatment approaches where previously only palliative treatments were possible. This lecture will provide a detailed introduction to radiotherapy treatment planning and will consist of three blocks:

1. The first part of the course considers the physical interactions of radiation in tissue. The physical interactions give rise to dose calculation algorithms, which are used to calculate the absorbed radiation dose based on a CT scan of the patient.

2. The second part considers the mathematical aspects of treatment planning. Mathematical optimization techniques are introduced, which are used in intensity-modulated radiotherapy to determine the external radiation fields that optimally irradiate the tumor while minimizing radiation dose to healthy organs.

3. The third part deals with additional aspects of central importance for radiotherapy planning. This includes biomedical imaging techniques for treatment planning and target delineation as well as image registration algorithms.

The lectures are followed by computational exercises where students implement the main components of a radiotherapy treatment planning systems in two dimensions in Matlab. Basic programming skills in Matlab (or willingness to learn) are needed for the exercises. Basic knowledge of calculus is needed, approximately corresponding to the 3rd year of a bachelor degree in physics, mathematics, computer science, engineering or comparable disciplines.

**Prerequisites**

Lecture slides and handouts.

**Notice**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: PHY471


Mind the enrolment deadlines at UZH:

https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

**Lecture notes**

Lecture slides and handouts.

**Objective**

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Other Elective Courses**

These courses may be suitable for the Medical Physics track. Please consult your track advisor.

<table>
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<th>Number</th>
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<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6</td>
<td>3+1U</td>
<td>E. Konukoglu, F. Yu</td>
</tr>
</tbody>
</table>

**Abstract**


**Objective**

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Prerequisites / notice
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites:
- Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
- The course language is English.

227-0965-00L Micro and Nano-Tomography of Biological Tissues W 4 credits 3G M. Stampani, F. Marone Welford

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanoscale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

Biography Courses

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<tr>
<th>Number</th>
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<th>Hours</th>
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<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
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</table>

Abstract

Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3D animation database/software to use ‘anatomical language’ to retrieve anatomical structures to understand basic medical terminology

Objective

To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

Content

- The Human Body: nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

Lecture notes
Lecture notes and handouts

Literature
Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008
Faller A., Schuenke M. The Human Body; Thieme 2004
Netter F. Atlas of human anatomy; Elsevier 2014

227-0945-00L Cell and Molecular Biology for Engineers I W 3 credits 2G to be announced

Abstract

Does not take place this semester.

The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective

After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes
Scripts of all lectures will be available.

Literature
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will not be assessed.

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges.

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Introduction into natural and polymeric biomaterials used for medical applications. The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Handouts and references therin.

Literature:

(updated: 01.11.2022 12:41)
I. Herrmann

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available.

Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and 3G.

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on microrobotics and micromanipulation techniques as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure and questions.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffracton is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of ultra complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopiles.

### Recommended Elective Courses

These courses are particularly recommended for the Molecular Bioengineering track. Please consult your track advisor if you wish to select other subjects.

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<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
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<td>Abstract</td>
<td>Microbotonics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<tr>
<td>Objective</td>
<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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<tr>
<td>Content</td>
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<td>- Scaling laws at micro/nano scales</td>
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<td>- Electrostatics</td>
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<td>- Electromagnetism</td>
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<td>- Observation tools</td>
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<td>- Materials and fabrication methods</td>
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<td></td>
<td>- Applications of biomedical microbots</td>
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<tr>
<td>Lecture notes</td>
<td>The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.</td>
<td></td>
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<tr>
<td>Prerequisites / notice</td>
<td>The lecture will be taught in English.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0905-00L</td>
<td>Medical Technology Innovation - From Concept to Clinics</td>
<td>W 4</td>
<td>credits</td>
<td>3G</td>
<td>I. Herrmann</td>
</tr>
</tbody>
</table>

Autumn Semester 2022
Abstract
Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

Objective
After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

Lecture notes
will be available on the moodle.

Literature
will be available on the moodle.

Prerequisites / notice
On site presence during (most) of the lectures highly encouraged!
Graded innovation project will require on-site presence.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Negotiation</td>
<td>assessed</td>
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</tbody>
</table>

Content
• Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
• Postulates of QM: Hilbert Spaces and Operators
• Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
• Density Operator
• Spin: Qubits, Bloch Equations, and NMR
• Entanglement
• Symmetries and Corresponding Operators
• Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
• Harmonic Oscillator: Creation and Annihilation Operators
• Identical Particles: Bosons and Fermions
• Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
• Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature

Supplementary material will be uploaded in Moodle.

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
<table>
<thead>
<tr>
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<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>not assessed</td>
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</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td></td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>Negotiation</td>
<td>not assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td></td>
<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</table>

<table>
<thead>
<tr>
<th>227-0385-10L Biomedical Imaging</th>
<th>W 6 credits 5G</th>
<th>S. Kozerke, K. P. Prüssmann</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.</td>
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<tr>
<td>Objective</td>
<td>Upon completion of the course students are able to:</td>
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<tr>
<td></td>
<td>• Explain the physical and mathematical foundations of diagnostic medical imaging systems</td>
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<td></td>
<td>• Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function</td>
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<td>• Design a basic diagnostic imaging system chain including data acquisition and data reconstruction</td>
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<td></td>
<td>• Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications</td>
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</tr>
<tr>
<td>Content</td>
<td>• Introduction (intro, overview, history)</td>
<td></td>
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<tr>
<td></td>
<td>• Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)</td>
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<td></td>
<td>• X-rays (production, tissue interaction, contrast, modular transfer function)</td>
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<tr>
<td></td>
<td>• X-rays (resolution, detection, digital subtraction angiography, Radon transform)</td>
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<tr>
<td></td>
<td>• X-rays (filtered back-projection, spiral computed tomography, image quality, dose)</td>
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<td></td>
<td>• Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PECT)</td>
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<td></td>
<td>• Nuclear imaging (detection principles, image reconstruction, kinetic modelling)</td>
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<td></td>
<td>• Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)</td>
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<tr>
<td></td>
<td>• Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)</td>
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<tr>
<td></td>
<td>• Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)</td>
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<tr>
<td></td>
<td>• Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)</td>
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<td></td>
<td>• Ultrasound (spatial and temporal resolution, phased arrays)</td>
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<tr>
<td></td>
<td>• Ultrasound (Doppler shift, implementations, applications)</td>
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<tr>
<td></td>
<td>• Summary, example exam questions</td>
<td></td>
</tr>
</tbody>
</table>

| Literature                    | Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011 |
| Prerequisites / notice        | Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming |

<table>
<thead>
<tr>
<th>227-0386-00L Biomedical Engineering</th>
<th>W 4 credits 3G</th>
<th>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.</td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.</td>
<td></td>
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</tbody>
</table>
History of BME and the role of biomedical engineers. Ethical issues related to BME.

Biomedical sensors both wearable and also biochemical sensors.

Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.

Bioinformatics: genomic and proteomic tools, databases and basic calculations.

Equations describing basic reactions and enzyme kinetics.

Medical optics: Optical components and systems used in hospitals.

Basic concepts of tissue engineering and organ printing.

Biomaterials and their medical applications.

Function of the heart and the circulatory system.

Transport and exchange of substances in the human body, compartment modeling.

The respiratory system.

Bioimaging.

Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes

Introduction to Biomedical Engineering

by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice

No specific requirements, BUT

ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while

HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making assessed

Media and Digital Technologies not assessed

Problem-solving not assessed

Project Management not assessed

Social Competencies

Communication not assessed

Cooperation and Teamwork not assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence not assessed

Sensitivity to Diversity not assessed

Negotiation not assessed

Personal Competencies

Adaptability and Flexibility not assessed

Creative Thinking not assessed

Critical Thinking not assessed

Integrity and Work Ethics not assessed

Self-awareness and Self-reflection not assessed

Self-direction and Self-management not assessed

Abstract

The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective

During this course the students will:

- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content

Lecture topics:

1. Introduction

Sources of bioelectronic signals

2. Membrane and Transport

3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals

5. Detection and Noise

6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes

7. Measuring potentials in solution and core conductance model

8. Measuring electronic signals with wearable electronics, EGG, EEG

9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording

10. Functional electric stimulation

11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)

12. Measuring neurons optically, fundamentals of optical microscopy

13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

Lecture notes

A detailed script is provided to each lecture including the exercises and their solutions.

Literature

Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice

The course requires an open attitude to the interdisciplinary approach of bioelectronics.

In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
### Micro and Nano-Tomography of Biological Tissues

227-0965-00L

**Abstract**
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

**Objective**

**Content**

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

**Lecture notes**
Available online

**Literature**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**

- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

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### Cross-Disciplinary Research and Development in Medicine and Engineering

227-0981-00L

**Abstract**

Cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course will bring together engineering students from ETH Zurich and medical students from the University of Zurich to experience the rewards and challenges of such interdisciplinary work in a project based learning environment.

**Objective**

The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since such differences become the most evident during actual collaborative work, the course is based on a current project in physiology research that combines medicine and engineering. For the engineering students, the specific aims of the course are to:

- Acquire a working understanding of the anatomy and physiology of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the found solutions to a cross-disciplinary audience.

**Content**

After a general introduction to interdisciplinary communication and detailed background on the collaborative project, the engineering students will team up with medical students to find solutions to a biomedical challenge. In the process, they will be supervised both by lecturers from ETH Zurich and the University of Zurich, receiving coaching customized to the project. The course will end with each team presenting their solution to a cross-disciplinary audience.

**Lecture notes**

Handouts and relevant literature will be provided.

**Prerequisites / notice**

**Fostered competencies**

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Problem-solving: assessed
  - Project Management: assessed

- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: assessed

**Lecture notes**

**Notice**

IMPORTANT: Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.

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### Surfaces, Interfaces and their Applications I

327-0505-00L

**Abstract**

After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

**Objective**

To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

**Fostered competencies**

- Analytical Competencies: assessed
- Problem-solving: assessed
- Project Management: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**

- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed

**Literature**

Available online

**Note**

Will be indicated during the lecture.
**Content**

- Introduction to Surface Science
- Physical Structure of Surfaces
- Surface Forces (static and dynamic)
- Adsorbates on Surfaces
- Surface Thermodynamics and Kinetics
- The Solid-Liquid Interface
- Electron Spectroscopy
- Vibrational Spectroscopy on Surfaces
- Scanning Probe Microscopy
- Introduction to Tribology
- Introduction to Corrosion Science

**Lecture notes**


**Literature**


**Prerequisites / notice**

**Chemistry**

General undergraduate chemistry including basic chemical kinetics and thermodynamics

**Physics**

General undergraduate physics including basic theory of diffraction and basic knowledge of crystal structures

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Problem-solving

- Personal Competencies
  - Creative Thinking
  - Critical Thinking

**327-1101-00L**  Biomineralization  

<table>
<thead>
<tr>
<th>Objective</th>
<th>The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / siliification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere / evolution / taxonomy of organisms.</td>
</tr>
</tbody>
</table>

**376-1622-00L**  Practical Methods in Tissue Engineering  

<table>
<thead>
<tr>
<th>Objective</th>
<th>The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prerequisites / notice</td>
<td>A Windows laptop (or Windows on Mac) is required for certain of the lab modules.</td>
</tr>
</tbody>
</table>

**402-0341-00L**  Medical Physics I  

| Objective | Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society. |

**402-0341-00L**  Medical Physics I  

| Objective | Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations. |

**Prerequisites**

- Physics: General undergraduate physics including basic theory of diffraction and basic knowledge of crystal structures

- Chemistry: General undergraduate chemistry including basic chemical kinetics and thermodynamics

**Literature**

3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

**Prerequisites / notice**

No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.
### Content

The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

### Lecture notes

A script will be provided.

### Prerequisites / notice

For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

### Literature

Information about relevant literature will be available in the lecture & in the lecture notes.

### Prerequisites / notice

Exercises are an integral part of the lecture.

### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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<td>Project Management</td>
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<td>Negotiation</td>
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</table>

### 529-0041-00L Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics

<table>
<thead>
<tr>
<th>Content</th>
<th>Objective</th>
<th>Abstract</th>
<th>W</th>
<th>6 credits</th>
<th>3G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).</td>
<td>Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.</td>
<td>Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.</td>
<td>R. Zenobi, B. Hättendorf, P. Sinués-Martinez-Lozano</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 529-0240-00L Chemical Biology - Peptides

| Content | Objective | Abstract | W | 6 credits | 3G |
| Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis. | Knowledge of the synthesis, properties and function of peptides in chemistry and biology. | An advanced course on the synthesis, properties and function of peptides in chemistry and biology. | H. Wennemers |

### 529-0615-01L Biochemical and Polymer Reaction Engineering

| Content | Objective | Abstract | W | 6 credits | 3G |
| Polymerization reactions and processes. Homogeneous and heterogeneous (emulsion) kinetics of free radical polymerization. Post treatment of polymer colloids. Bioprocesses for the production of molecules and therapeutic proteins. Kinetics and design of aggregation processes of macromolecules and proteins. | The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior. | Polymerization reactions and processes. Homogeneous and heterogeneous (emulsion) kinetics of free radical polymerization. | P. Arosio |

### 535-0423-00L Drug Delivery and Drug Targeting

| Content | Objective | Abstract | W | 2 credits | 1.5V |
| The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria. | | Drug delivery and drug targeting | J.-C. Leroux |
Objective

The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content

The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes

Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature


Further references will be provided in the course.
Prerequisites / notice
The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc.

This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April.

Please note that the number of ECTS credits and the actual work load are disconnected.

---

### Other Elective Courses

*These courses may be suitable for the Molecular Bioengineering track. Please consult your track advisor.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberl, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
</tbody>
</table>

**Abstract**
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Objective**
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Content**
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Lecture notes**
Updated handouts will be provided during the class.

**Literature**
Current literature references will be provided during the lectures.

**Prerequisites / notice**
English
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

---

### Biology Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
</tbody>
</table>

**Abstract**
Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3D animation database/software to use anatomical language to retrieve anatomical structures to understand basic medical terminology

**Objective**
To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

**Content**
- The human Body: nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

**Lecture notes**
Lecture notes and handouts

**Literature**
Silbernagl S., Despopoulos A. Color Atlas of Physiology; Thieme 2008
Faller A., Schuenke M. The Human Body; Thieme 2004
Netter F. Atlas of human anatomy; Elsevier 2014

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>to be announced</td>
</tr>
</tbody>
</table>

**Abstract**
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

**Objective**
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

**Content**
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells. In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

**Lecture notes**
Scripts of all lectures will be available.

**Literature**
Biological Methods for Engineers (Basic Lab)  

Number of participants limited to 10.

Abstract
The course during 7 afternoons (13h to 18h) covers basic laboratory skills and safety, cell culture, protein analysis, RNA/DNA Isolation and RT-PCR. Each topic will be introduced, followed by practical work at the bench. Presence during the course is mandatory.

Objective
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Content
The goal of this laboratory course is to give students practical exposure to basic techniques of cell and molecular biology.

Prerequisites / notice
Enrollment is limited and students from the Master's programme in Biomedical Engineering (BME) have priority.

Projects and Laboratory Courses

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, “in this paper” paragraph, scientific part, summary, equations, figures)

* Topic 2: Structure of Scientific Presentations

* Topic 3: Citation Rules and Citation Software

* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html

ETH "Scientific Integrity", see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1772-10L</td>
<td>Semester Project</td>
<td>O</td>
<td>12 credits</td>
<td>20A</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Registration in myStudies required!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The semester project is designed to train the students in solving specific biomedical engineering problems. This project uses the technical and social skills acquired during the master's program. The semester project is advised by a professor.</td>
<td></td>
<td></td>
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<tr>
<td>Objective</td>
<td>see above</td>
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</tbody>
</table>

Additional Projects and Laboratory Courses (ONLY for Progr. Reg. 2020)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1772-20L</td>
<td>Semester Project 2</td>
<td>W</td>
<td>12 credits</td>
<td>20A</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Only for Programme Regulations 2020.</td>
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<tr>
<td></td>
<td>Registration in myStudies required!</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The semester project is designed to train the students in solving specific biomedical engineering problems. This project uses the technical and social skills acquired during the master's program. The semester project is advised by a professor.</td>
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<tr>
<td>Objective</td>
<td>see above</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1750-00L</td>
<td>Internship in Industry ■</td>
<td>W</td>
<td>12 credits</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td>Only for Biomedical Engineering MSc (Programme Regulations 2020).</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Registration in myStudies required!</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The main objective of the 12-week internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>see above</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1760-00L</td>
<td>Research Project (long)</td>
<td>W</td>
<td>24 credits</td>
<td>40A</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Only for Biomedical Engineering MSc (Programme Regulations 2020).</td>
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<tr>
<td></td>
<td>Registration in myStudies required!</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The aim of the long research project is to perform a larger (exploratory) scientific study or a larger development project in a team. The duration of this project is at least four months (full-time) and it is finished with a report and/or prototype.</td>
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</tr>
<tr>
<td>Objective</td>
<td>see above</td>
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</tbody>
</table>

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0 credits</td>
<td></td>
<td>U. Koch</td>
</tr>
<tr>
<td></td>
<td>Strongly recommended prerequisite for Semester Projects and Master Theses at D-ITET (MSc BME, MSc EEIT, MSc EST).</td>
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<td></td>
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<tr>
<td></td>
<td>Registration in myStudies required!</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
| Objective | - Knowledge on structure and content of scientific texts and presentations  
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article  
- Discussion of the practice of proper citing and scientific integrity  |
| Content  | * Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, "in this paper" paragraph, scientific part, summary, equations, figures)  
* Topic 2: Structure of Scientific Presentations  
* Topic 3: Citation Rules and Citation Software  
* Topic 4: Guidelines for Scientific Integrity  |

| Literature | ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html  
ETH "Scientific Integrity", see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html  |

| Prerequisites / notice | Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future. |

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1700-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>40D</td>
<td>Professors</td>
</tr>
</tbody>
</table>
|          | Admission only if all the following apply:  
a. bachelor program successful completed;  
b. any additional requirements necessary to gain admission to the master program BME have been successfully completed;  
c. both the semester project and (if applicable) the internship successfully completed.  
Registration in myStudies required! |
|          | The masters program culminates in a six months research project which addresses a scientific research questions on one's chosen area of specialization. The masters thesis is supervised by a program-affiliated faculty member and the topic must be approved by the track advisor. |
| Objective| see above                                 |      |         |       |           |

Science in Perspective

| Recommended Science in Perspective (Type B) for D-ITET  |

<p>| see Science in Perspective: Language Courses ETH/UZH  |</p>
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0970-00L</td>
<td>Research Topics in Biomedical Engineering</td>
<td>Z</td>
<td>0 credits</td>
<td>1K</td>
<td>K. P. Prüssmann, S. Kozerke, M. Stampanoni, K. Stephan, J. Vöröcs</td>
</tr>
<tr>
<td></td>
<td><em>Does not take place this semester.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Current topics in Biomedical Engineering presented by speakers from academia and industry.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Getting insight into actual areas and problems of Biomedical Engineering and Health Care.</td>
</tr>
<tr>
<td>227-0980-00L</td>
<td>Seminar on Biomedical Magnetic Resonance</td>
<td>Z</td>
<td>0 credits</td>
<td>1S</td>
<td>K. P. Prüssmann, S. Kozerke, M. Weiger Senften</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Current developments and problems of magnetic resonance imaging (MRI)</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Getting insight into advanced topics in magnetic resonance imaging</td>
</tr>
</tbody>
</table>

**Biomedical Engineering Master - Key for Type**

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Biotechnology Master

Master Studies (Programme Regulations 2021)

Core Courses

Courses

Students need to acquire a total of 6 ECTS in lectures in this category.
The list of core courses is a closed list, no other course can be added to this category.
Students need to pass both lectures offered in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0101-00L</td>
<td>Systems Genomics</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>B. Truettlein, C. Beisel, Z. He</td>
</tr>
</tbody>
</table>

Abstract
This course is an introduction to the wide field of Genomics. It addresses how fundamental questions in biological systems are studied using methods in genomics and how the resulting data is analysed to make qualitative interpretations of biological phenomena.

Objective
The goal of this course is to get detailed insights in how state-of-the-art DNA sequencing technologies can be applied for a qualitative and quantitative description of molecular and cellular processes and function. Students will learn how to analyse RNA-seq / transcriptomics data and make biological interpretations in a quantitative manner.

Content
This course will be a mix of lecture sessions, hands-on computational data analysis using public datasets and seminars discussing own results in the context of the published studies. In the lectures we will introduce current Next-Generation Sequencing technologies and their application to address basically all facets of modern biology and biomedical research. We will cover the major sample processing methods used for investigating functional genomic aspects like transcriptome and chromatin profiling, review recent advances in cancer genome sequencing and give an overview of public big data sequencing projects (ENCOD, GTEX, TCGA,...).

For the computational data analysis we will focus on differential gene expression profiling (RNA-seq) experiments that have been selected from fascinating published biological studies. Data analysis based on R will follow a detailed tutorial describing all required steps of sequence read processing and will be conducted in small groups to enable every student hands-on experience.

Lecture notes
The PowerPoint presentations of the lectures as well as other course material relevant for an active participation will be made available online.

Research Project and Industry Internship

Students can choose between Research Project OR Industry Internship. Duration: 12 weeks full-time min.
Must be carried out in a different research group/company than the master's thesis.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course provides an overview of modern concepts of bioengineering across different levels of complexity, from single molecules to systems, microscaled reactors to production environments, and across different fields of applications.

Objective
Students will be able to recognize major developments in bioengineering across different organs and levels of complexity and be able to relate it to major technological and conceptual advances in the underlying sciences.

Content
Molecular and cellular engineering; Synthetic biology; Engineering strategies in biology; from single molecules to systems; downsampling bioengineering; Bioengineering in chemistry, pharmaceutical sciences, and diagnostics, personalized medicine.

Research Project duration: 12 weeks, completed with a written report.

Lecture notes
Handouts during class

Literature
Will be announced during the course

Fostered competencies
Subject-specific Competencies: assessed

Techniques and Technologies: assessed

Critical Thinking: assessed

Master's Thesis

Students can only start with their master's thesis if:
a. The BSc programme has been completed successfully
b. Assigned additional requirements for the admission to the master's degree programme have been passed
c. At least 64 ECTS have been acquired for the master's degree programme, including 22 ECTS in the core course category and the 16 ECTS in the research projects and internships category

Abstract
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is carried out under the supervision of a professor in a research group of the D-BSSE, usually at the D-BSSE. Students are free to choose the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0900-10L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>44</td>
<td>91D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 408 of 2416


► Master Studies (Programme Regulations 2017)

►► Core Courses

Students need to acquire a total of 8 ECTS in lectures in this category.

The list of core courses is a closed list, no other course can be added to this category.

Students need to pass both lectures offered in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract: This course provides an overview of modern concepts of bioengineering across different levels of complexity, from single molecules to systems, microscaled reactors to production environments, and across different fields of applications.

Objective: Students will be able to recognize major developments in bioengineering across different organisms and levels of complexity and be able to relate it to major technological and conceptual advances in the underlying sciences.

Content: Molecular and cellular engineering; Synthetic biology; Engineering strategies in biology; from single molecules to systems; downscaling bioengineering; Bioengineering in chemistry, pharmaceutical sciences, and diagnostics, personalized medicine.

Lecture notes: Handouts during class

Literature: Will be announced during the course

Fostered competencies: Subject-specific Competencies - Concepts and Theories; Techniques and Technologies; Personal Competencies - Critical Thinking

► Research Projects and Internship

Students need to acquire a total of 20 ECTS in this category.

Either choose Research Project I (8 ECTS) and Research Project II (12 ECTS)

Or choose Research Project I (8 ECTS) and Industry Internship (12 ECTS)

Instead of Research Project I (8 ECTS) students may also choose Synthetic Biology II (8 ECTS)

►► Research Projects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0802-00L</td>
<td>Research Project I</td>
<td>O</td>
<td>8</td>
<td>23A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract: In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.

Research Project I duration: 8 weeks

Objective: Students get acquainted with scientific working methods and deepen their knowledge in a particular research area

<table>
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<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0803-00L</td>
<td>Research Project II</td>
<td>W</td>
<td>12</td>
<td>34A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract: Enrollment only for students that don’t do an industry internship but two research projects.

In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.

Research Project II duration: 12 weeks

Objective: Students get acquainted with scientific working methods and deepen their knowledge in a particular research area

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0507-00L</td>
<td>Synthetic Biology II</td>
<td>W</td>
<td>8</td>
<td>4A</td>
<td>S. Panke, Y. Benenson, J. Stelling</td>
</tr>
</tbody>
</table>

Abstract: 7 months biological design project, during which the students are required to give presentations on advanced topics in synthetic biology (specifically genetic circuit design) and then select their own biological system to design. The system is subsequently modeled, analyzed, and experimentally implemented. Results are presented at an international student competition at the MIT (Cambridge).

Objective: The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.

Content: Presentations on advanced synthetic biology topics (e.g. genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence, (DNA synthesis external,) implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (www.igem.org).

Lecture notes: Handouts during course

Prerequisites / notice: The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc.

This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April.

Please note that the number of ECTS credits and the actual work load are disconnected.

►► Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0804-00L</td>
<td>Industry Internship</td>
<td>W</td>
<td>12</td>
<td>34A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract: Industry internship of at least 12 weeks, completed with a written report.
Objective
Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the courses.

Prerequisites / notice
The students look for a placement themselves.

Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0900-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>40</td>
<td>9D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Abstract
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is carried out under the supervision of a professor in a research group of the D-BSSE, usually at the D-BSSE. Students are free to choose the area.

Objective
In the Master thesis students prove their ability to independent, structured and scientific working.

Practical Training

All listed lab courses are mandatory.

For Students in Biotechnology Master, Programme Regulation 2021: 16 ECTS in this category are mandatory.

For Students in Biotechnology Master, Programme Regulation 2017: 14 ECTS in this category are mandatory.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0201-00L</td>
<td>Lab Course: Methods in Cell Analysis and Laboratory Automation</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>T. Horn</td>
</tr>
</tbody>
</table>

Abstract
The lab course is open for MSc Biotechnology students only.

Objective
- to understand the technical and physical principles of light microscopes and flow cytometers
- to have hands-on experience in the use of these technologies to analyze image real samples
- to be able to run a basic analysis of the data and images obtained with flow cytometers and microscopes
- to get introduced to liquid handling (pipetting) robotics and learn how to implement a basic workflow

Content
The practical course will have five units at 2 days each (total 10 days):
1. Flow Cytometry:
   a. Introduction to Flow Cytometry
   b. Practical demonstration on flow cytometry analyzers and flow cytometry cell sorters
   c. Flow cytometry sample preparation
   d. Learn how to use flow cytometry equipment to analyze and sort fluorescence-labeled cells
2. Light microscopy
   a. Learn how to build a microscope and understand the underlying physical principles
   b. Learn how to use a modern automated wide field fluorescence microscope
   c. Use this microscope to automatically acquire images of a cell culture assay to analyze the dose-dependent effect of a drug treatment
3. Image Analysis
   a. Introduction to the fundamentals of image analysis
   b. Learn the basics of the image analysis software Fiji/ImageJ
   c. Use Fiji/ImageJ to analyze the images acquired during the microscopy exercise
4. Laboratory Automation
   a. Introduction to the basics of automated liquid handling/ lab robotics
   b. See examples on using lab automation for plasmid library generation and cell cultivation
   c. Learn how to program and execute a basic pipetting workflow including liquid handling and labware transfers on Tecan and Hamilton robotic systems
5. Presentations
   a. Each student will be assigned to an individual topic of the course and will have to prepare a presentation on it.
   b. Presentations and discussion in form of a Colloquium

Lecture notes
You will find further information on the practical course and the equipment at:
https://www.bsse.ethz.ch/scf
https://www.bsse.ethz.ch/lab

Literature
- Microscopy: Murphy and Davidson, Fundamentals of Light Microscopy and Electronic Imaging, John Wiley & Sons, 2012
- Flow Cytometry: Shapiro, Practical Flow Cytometry, John Wiley & Sons, 2005

Prerequisites / notice
The following knowledge is required for the course:
- basic laboratory methods
- basic physics of optics (properties of light, refraction, lenses, fluorescence)
- basic biology of cells (cell anatomy and physiology)

Lab Course: Microsystems and Microfluidics in Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0203-00L</td>
<td>Lab Course: Microsystems and Microfluidics in Biology</td>
<td>O</td>
<td>3</td>
<td>5P</td>
<td>P. S. Dittrich, A. Hiertemann</td>
</tr>
</tbody>
</table>

Abstract
This practical course is an introduction to microsystems technology and microfluidics for the life sciences. It includes basic concepts of microsystem design, fabrication, and assembly into an experimental setup. Biological applications include a variety of measurements of cellular and tissue signals and subsequent analysis.

Objective
The students are introduced to the basic principles of microsystems technology. They get acquainted with practical scientific work and learn the entire workflow of (a) understanding the theoretical concept, (b) planning the experiment, (c) engineering of the needed device, (d) execution of the experiment and data acquisition, (e) data evaluation and analysis, and (f) reporting and discussion of the results.

Content
The practical course will consist of a set of 4 experiments.

Lecture notes
Notes and guidelines will be provided at the beginning of the course.

Literature
Prerequisites / notice
The practical course will consist of a set of 4 experiments. For each experiment, the student will be required to
- understand the theoretical concept behind the experiment
- plan the experiment
- engineer the devices
- execute the experiments and acquire data
- evaluate and analyze the data
- report and discuss the results
A good quality of the final report will be expected and be an important criterion.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

636-0204-00L Lab Course: Microbial Biotechnology
The lab course is open for MSc Biotechnology students only.

Objective
Students will learn the foundations of monoseptic working practice and create and screen microbial libraries for identification of strains expressing different fluorescent protein (XFP) levels

Content
Block A: Handling and preparation of microbial libraries
D1: Introduction to microbiological cultures and monoseptic working techniques.
D2: Plasmid-based expression systems and variation of XFP synthesis levels via site-directed RBS mutagenesis.
Block B: Library screening
D3: In vivo screening for XFP expression levels.
D4: Analysis of XFP levels via SDS-PAGE analysis. RBS-sequencing.
Block C: Hit recovery and validation
D5: In silico analysis of RBS variants.
D6: Cellular XFP content for selected variants at different culture conditions.
Block D: Data analysis and presentation
D7: Protein expression analysis. Q&A for reports and presentations.
D8: Final presentations and wrap-up.

Lecture notes
Material will be provided during the course.

Literature
(3) Salis HM. "The ribosome binding site calculator." Methods Enzymol. 2011

General introduction to microbiology:
(6) Pirt JS. "Principles of microbe and cell cultivation." Blackwell Scientific Publications 1975

Advanced Courses
Students need to acquire a total of 24 ECTS in this category.
The list of advanced courses is a closed list, no other course can be added to this category.

Biomelecular-Orientated

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0103-00L</td>
<td>Microtechnology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Hierlemann</td>
</tr>
</tbody>
</table>

Abstract
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based micro-devices and -systems and all related microfabrication processes.

Objective
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various micro-devices and systems.

Content
Introduction to microtechnology, semiconductors, and micro electro mechanical systems (MEMS)

- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode.
- Silicon processing and fabrication steps
- Silicon crystal structure and manufacturing
- Thermal oxidation
- Doping via diffusion and ion implantation
- Photolithography
- Thin film deposition: dielectrics and metals
- Wet etching & bulk micromachining
- Dry etching & surface micromachining
- Microtechnological processing and fabrication sequence
- Optional: Packaging

Lecture notes
Handouts in English

Literature
Prerequisites / notice

Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

The information on the web can be updated until the beginning of the semester.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed

Social Competencies
Communication assessed

Personal Competencies
Critical Thinking assessed

636-0104-00L Biophysical Methods W 4 credits 3G D. J. Müller

Abstract

Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective

Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content

The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:

- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI Imaging
- Scanning tunnelling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations

Lecture notes

Hand out will be given to students at lecture.

Literature

Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press

Prerequisites / notice

The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

636-0105-00L Introduction to Biological Computers W 4 credits 3G Y. Benenson

Abstract

Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanotechnology and synthetic biology.

Objective

The course has the following objectives:

* Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms
* Introduce basic theories of computation
* Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include

- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly
* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations
* Foster creativity, research and communication skills through semester-long “Design challenge” assignment in the broad field of biological computing and biological circuit engineering.
Lecture 1. Introduction: what is molecular computation (part I)?

* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines

1st hour

* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour

* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation

* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4. Classical DNA computing

* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly

* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes

* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits

* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I

* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II

* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I

* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II

* RNAi logic circuits
* RNAi-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits

* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics

* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
As a way of general introduction, the following two review papers could be useful:


Benenson, Y. Biocomputers: from test tubes to live cells. Molecular Biosystems 2009, 5:675:685

Basic knowledge of molecular biology is assumed.

### 636-0108-00L

**Course Title:** Biological Engineering and Biotechnology  
**Code:** W 4 credits 3V M. Fussenegger

**Abstract:** Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.  

**Objective:** Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content:**  

**Lecture notes**  
Handout during the course.

### 636-0107-00L

**Course Title:** Microbial Biotechnology  
**Code:** W 4 credits 3G S. Panke

**Abstract:** Students of this course know and evaluate modern methods of microbial biotechnology and enzyme technology and understand their relation to modern applications of microbial biotechnology.

**Objective:** Students of this course know and can evaluate modern methods of microbial biotechnology and enzyme technology and understand their relation to modern applications of microbial biotechnology.

**Content:** The course will cover in its main part selected fundamental and advanced topics and methodologies in microbial molecular biotechnology. Major topics include I) Microbial physiology of microbes (prokaryotes and selected fungi), II) Applications of Microbial Biotechnology, III) Enzymes - advanced kinetics and engineering, IV) Principles of in vivo directed evolution, V) System approaches to cell engineering/metabolic engineering, and VI) Trends in Microbial Biotechnology. The course is a mix of lectures and different exercise formats.

**Lecture notes**  
Notes will be provided in the forms of handouts.

**Literature**  
The course will use selected parts of textbooks and then original scientific publications and reviews.

**Fostered competencies**

- **Subject-specific Competencies:** Concepts and Theories assessed  
- **Techniques and Technologies** assessed
- **Method-specific Competencies:** Analytical Competencies assessed
- **Social Competencies:** Communication assessed  
- **Cooperation and Teamwork** assessed
- **Personal Competencies:** Self-direction and Self-management assessed

### 636-0018-00L

**Course Title:** Data Mining I  
**Code:** W 6 credits 3G+2A K. M. Borgwardt

**Abstract:** Data Mining, the search for statistical dependencies in large databases, is of utmost important in modern society, in particular in biological and medical research. This course provides an introduction to the key problems, concepts, and algorithms in data mining, and the applications of data mining in computational biology.

**Objective:**  
The goal of this course is that the participants gain an understanding of data mining problems and algorithms to solve these problems, in particular in biological and medical applications.

**Content:** The goal of the field of data mining is to find patterns and statistical dependencies in large databases, to gain an understanding of the underlying system from which the data were obtained. In computational biology, data mining contributes to the analysis of vast experimental data generated by high-throughput technologies, and thereby enables the generation of new hypotheses.

In this course, we will present the algorithmic foundations of data mining and its applications in computational biology. The course will feature an introduction to popular data mining problems and algorithms, reaching from classification via clustering to feature selection. This course is intended for both students who are interested in applying data mining algorithms and students who would like to gain an understanding of the key algorithmic concepts in data mining.

**Tentative list of topics:**

1. Distance functions  
2. Classification  
3. Clustering  
4. Feature Selection

**Lecture notes**  
Course material will be provided in form of slides.

**Literature**  
Will be provided during the course.

**Prerequisites / notice**  
Basic understanding of mathematics, as taught in basic mathematics courses at the Bachelor's level.

### 636-0550-00L

**Course Title:** Biomolecular Nanotechnology  
**Code:** W 4 credits 2V+1U M. Nash

**Abstract:** Biomolecular nanotechnology is a broad field that focuses on the study and science of biological materials including DNA, RNA and proteins at lengths below 10 nm. This is a broad overview of the topic with a focus on current research themes.

**Objective:** The objective is to familiarise the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.
Content
Introduction to biomacromolecules; Measurement techniques for characterisation of biomacromolecules; Fundamentals of molecular recognition; Recombinant DNA; Protein engineering; Directed evolution; Protein folding; Polymers; Elastin-like polypeptides; Intelligent materials; Spatially localized hydrogels; Mechanical properties of proteins and macromolecules; Single-molecule force spectroscopy

Literature
Representative literature:
(1) Alberts, Molecular Biology (Ch.2 Cellular chemistry).
(2) Ratner, Biomaterials Science (Ch. 2.3, 2.4 Polymers & hydrogels).
(3) Walsh, Protein Biochemistry, (Ch. 2, Protein Structure).

636-0117-00L Mathematical Modelling for Bioengineering and Systems Biology
W 4 credits 3G D. Iber

Abstract
Basic concepts and mathematical tools to explore biochemical reaction kinetics and biological network dynamics.

Objective
The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course covers basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

Content
Biochemical Reaction Modelling

636-0118-00L Introduction to Dynamical Systems with Applications
W 4 credits 3G M. H. Khammash, A. Gupta

Abstract
Many physical systems are dynamic and are characterized by internal variables that change with time. Describing the quantitative and qualitative features of this change is the topic of dynamical systems theory. Dynamical systems arise naturally in virtually all scientific disciplines including physics, biology, chemistry and engineering. This course is a broad introduction to the topic dynamical systems.

Objective
The goal of this course is to introduce the student to dynamical systems and to develop a solid understanding of their fundamental properties. The theory will be developed systematically, focusing on analytical methods for low dimensional systems, geometric intuition, and application examples from biology. Computer simulations using matlab will be used to demonstrate various concepts.

Content
A dynamical view of the world; the importance of nonlinearity; solutions of differential equations; solving equations on the computer; the phase plane; fixed points and stability; linear stability analysis; classifications of linear systems; Liapunov functions and nonlinear stability; cycles and oscillations; bifurcations and bifurcation diagrams. Many biological examples will be used through the course to demonstrate the concepts.

Lecture notes
Will be provided as needed.

Literature

636-0109-00L Stem Cells: Biology and Therapeutic Manipulation
W 4 credits 3G T. Schroeder

Abstract
Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

Objective
Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

Content
We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies

Social Competencies
- Communication
- Self-presentation and Social Influence

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics

636-0123-00L Problem-Based Approach to Spatial Biology
Does not take place this semester.
W 4 credits 3G A. Moor

Abstract
This course entails lectures in tissue physiology, spatial methodologies and grantsmanship. In the project part, small working groups will perform the entire scientific process around formulating a research proposal with the aid of tutors.
Objective
The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will obtain the necessary toolkits to independently identify open research problems in various areas of spatial biology, to address these problems with suitable experimental strategies, and to formulate their approach in a research proposal.

Content
We will use a problem-based approach to explore the way in which single cells collaborate within tissues to achieve their common functions. A thorough comprehension of these tissue components is crucial for advancing our knowledge of normal homeostasis and pathophysiology; disrupted cellular interactions can lead to decreased tissue function or even carcinogenesis.

The project work will be conducted in small groups in guidance of tutors. Each group will focus on a different topic in spatial biology and will review the corresponding literature. They will identify open problems of interest in this area and will summarize their findings in a short, written review. The students will then develop an appropriate experimental strategy to address a question of interest and write a research proposal that features their approach. The final stage of the project work enable the students to practice the presentation of their research proposals and critical evaluation.

Literature
Will be provided during the course.

Prerequisites / notice
This course requires independent group work.

System-Orientated

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>636-0103-00L</td>
<td>Microtechnology</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
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Abstract
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and -systems and all related microfabrication processes.

Objective
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.

Content
Introduction to microtechnology, semiconductors, and micro electro mechanical systems (MEMS)

- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode.
- Silicon processing and fabrication steps
  - Silicon crystal structure and manufacturing
  - Thermal oxidation
  - Doping via diffusion and ion implantation
  - Photolithography
  - Thin film deposition: dielectrics and metals
  - Wet etching & bulk micromachining
  - Dry etching & surface micromachining
  - Microtechnological processing and fabrication sequence
    - Optional: Packaging

Lecture notes
Handouts in English

Literature

Prerequisites / notice
Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

Fostered competencies
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

636-0104-00L Biophysical Methods W 4 credits 3G D. J. Müller

Abstract
Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective
Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content
The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:
- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI Imaging
- Scanning tunnelling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations
Abstract

Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanotechnology and synthetic biology.

Objective

* Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms

* Introduce basic theories of computation

* Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include
- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly

* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations

* Foster creativity, research and communication skills through semester-long "Design challenge" assignment in the broad field of biological computing and biological circuit engineering.
Lecture 1. Introduction: what is molecular computation (part I)?

* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines

1st hour

* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour

* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation

* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4. Classical DNA computing

* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly

* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes

* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits

* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I

* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II

* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I

* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II

* RNAi logic circuits
* RNAi-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits

* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics

* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
Data Mining, the search for statistical dependencies in large databases, is of utmost importance in modern society, in particular in biological and medical research. This course provides an introduction to the key problems, concepts, and algorithms in data mining, and the applications of data mining in computational biology.

### Objective

The goal of this course is that the participants gain an understanding of data mining problems and algorithms to solve these problems, in particular in biological and medical applications.

### Content


In this course, we will present the algorithmic foundations of data mining and its applications in computational biology. The course will feature an introduction to popular data mining problems and algorithms, reaching from classification via clustering to feature selection. This course is intended for both students who are interested in applying data mining algorithms and students who would like to gain an understanding of the key algorithmic concepts in data mining.

Tentative list of topics:

1. Distance functions
2. Classification
3. Clustering
4. Feature Selection

### Literature

- Fussenegger, M. H. Khammash. Introduction to Dynamical Systems with Applications to Biology

### Prerequisites / notice

Basic understanding of mathematics, as taught in basic mathematics courses at the Bachelor's level.
The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will not be assessed.


A. Moor

4 credits

T. Schroeder

636-0109-00L

Stem Cells: Biology and Therapeutic Manipulation

| Objective | Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells. |
| Content | We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application. |
| Topics will include: | Embryonic and adult stem cells and their niches, Induced stem cells by directed reprogramming, Relevant basic cell biology and developmental biology, Relevant molecular biology, Cell culture systems, Cell fates and their molecular control by transcription factors and signalling pathways, Cell reprogramming, Disease modelling, Tissue engineering, Bioimaging, Bioinformatics, Single cell technologies |

Fostered competencies

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Communication
- Social Competencies: Self-presentation and Social Influence
- Personal Competencies: Critical Thinking, Integrity and Work Ethics

636-0123-00L

Problem-Based Approach to Spatial Biology

| Objective | This course entails lectures in tissue physiology, spatial methodologies and grantsmanship. In the project part, small working groups will perform the entire scientific process around formulating a research proposal with the aid of tutors. |
| Content | The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will obtain the necessary toolkits to independently identify open research problems in various areas of spatial biology, to address these problems with suitable experimental strategies, and to formulate their approach in a research proposal. |
| Literature | We will use a problem-based approach to explore the way in which single cells collaborate within tissues to achieve their common functions. A thorough comprehension of these tissue components is crucial for advancing our knowledge of normal homeostasis and pathophysiology; disrupted cellular interactions can lead to decreased tissue function or even carcinogenesis. |
| Prerequisites / notice | The project work will be conducted in small groups in guidance of tutors. Each group will focus on a different topic in spatial biology and will review the corresponding literature. They will identify open problems of interest in this area and will summarize their findings in a short, written review. The students will then develop an appropriate experimental strategy to address a question of interest and write a research proposal that features their approach. The final stage of the project work enable the students to practice the presentation of their research proposals and critical evaluation. |

Electives

The electives list in the ETH course catalogue is an open list, and the courses listed in the ETH course catalogue provide just examples for possible elective courses, e.g. a selection of eligible courses. Students are expected to look for relevant courses in the ETH and University of Basel course catalogue and ask their mentor for approval. Courses from the advanced course category may also be taken as electives.

We particularly recommend browsing the University of Basel course catalogue for elective courses of relevant master's degree programs (using the filter "programe structure" on the course catalogue website), such as for example: Biomedical Engineering, Chemistry, Drug Sciences, Epidemiology, Infection Biology, Molecular Biology, Nanosciences.

E. A.

4 credits

A. Moor

Does not take place this semester.

636-0015-00L

An Introduction to Probability Theory and Stochastic Processes with Applications to Biology

| Objective | Biology is becoming increasingly quantitative and mathematical modeling is now an integral part of biological research. In many biological processes, ranging from gene-expression to evolution, randomness plays an important role that can only be understood using stochastic models. This course will provide the students with a theoretical foundation for developing such stochastic models and analyzing phenomena. The aim of this course is to introduce certain topics in Probability Theory and Stochastic Processes that have been specifically selected with an eye on biological applications. This course will teach the students the tools and techniques for modeling and analyzing random phenomena. Throughout the course, several biological applications will be discussed and students will be encouraged to do additional reading based on their research interests. |
| Abstract | Biology is becoming increasingly quantitative and mathematical modeling is now an integral part of biological research. In many biological processes, ranging from gene-expression to evolution, randomness plays an important role that can only be understood using stochastic models. This course will provide the students with a theoretical foundation for developing such stochastic models and analyzing phenomena. The aim of this course is to introduce certain topics in Probability Theory and Stochastic Processes that have been specifically selected with an eye on biological applications. This course will teach the students the tools and techniques for modeling and analyzing random phenomena. Throughout the course, several biological applications will be discussed and students will be encouraged to do additional reading based on their research interests. |
| Number | 636-0015-00L |
| Title | An Introduction to Probability Theory and Stochastic Processes with Applications to Biology |
| Type | W |
| ECTS | 4 |
| Hours | 3G |
The half of the course will cover the basics of Probability Theory while the second half will delve into the theory of Stochastic Processes. Below is the list of topics that will be covered in the course.

1. The mathematical representation of random phenomena: The probability space, properties of the probability measure, Independence of events, Conditional probability and Bayes formula, applications to parameter inference.


3. Convergence of Random Variables: Modes of convergence, Laws of large numbers, the central limit theorem, the law of the iterated logarithm. Applications to the analysis of cell population data.


Content

The course will be structured as follows:

1. Probability Theory
2. Stochastic Processes
3. Applications of Stochastic Processes in Biology
4. Advanced Topics in Stochastic Processes

Literature

While no specific textbook will be followed, much of the material and homework problems will be taken from the following books:

- D. Iber
- C. Magnus, T. Stadler
- T. Vaughan

This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on

3G+2A

Development of cerebral cortex, hippocampus, motor system, olfactory system, visual system, auditory system, somatosensory system,

Molecular Medicine I

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Developmental Neuroscience
- Molecular Medicine
- Spatio-Temporal Modelling in Biology

The first half of the course will cover the basics of Probability Theory while the second half will delve into the theory of Stochastic Processes. Below is the list of topics that will be covered in the course.

1. The mathematical representation of random phenomena: The probability space, properties of the probability measure, Independence of events, Conditional probability and Bayes formula, applications to parameter inference.


3. Convergence of Random Variables: Modes of convergence, Laws of large numbers, the central limit theorem, the law of the iterated logarithm. Applications to the analysis of cell population data.


Abstract

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phyldynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phyldynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- * Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-B SSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

636-0017-00L Computational Biology W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Stadler

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phyldynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phyldynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- * Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-B SSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

636-0501-00L Advanced Immunology I W 2 credits 2V external organisers

Does not take place this semester.

Abstract

This course aims at deepening the understanding of human immune responses against infectious diseases like malaria, tuberculosis and HIV and their interaction with novel emerging diseases including Dengue and Pegivirus infections.

Objective

The student will be familiarized with cutting approaches for vaccine development including human challenge models and human monoclonal antibodies.

636-0511-00L Developmental Neuroscience I W 2 credits 2V external organisers

Does not take place this semester.

Abstract

Development of cerebral cortex, hippocampus, motor system, olfactory system, visual system, auditory system, somatosensory system, navigation and memory systems, developmental disorders (autism, stem cells in the developing, adult and diseased brain).

636-0515-00L Molecular Medicine I W 2 credits 2V external organisers

This lecture series will introduce biologists to the mechanisms that cause human diseases. Emphasis will be on the genetic and environmental factors that lead to diseases, and how this knowledge can be used to develop diagnostic and therapeutic procedures.

636-0706-00L Spatio-Temporal Modelling in Biology W 4 credits 3G D. Iber

This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on mechanisms and concepts, but mathemating and numerical techniques are introduced as required. Biological examples discussed in the course provide an introduction to key concepts in developmental biology.
**Objective**

Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

**Content**

1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

**Lecture notes**

All lecture material will be made available online via Moodle.

**Literature**

The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:

- Murray, Mathematical Biology, Springer
- Forgacs and Newman, Biological Physics of the Developing Embryo, CUP
- Keener and Sneyd, Mathematical Physiology, Springer
- Fall et al, Computational Cell Biology, Springer
- Szallasi et al, System Modeling in Cellular Biology, MIT Press
- Wolkenhauer, Systems Biology
- Kreyszig, Engineering Mathematics, Wiley

Prerequisites / notice

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

**636-0119-00L Introduction to Statistics and R**

- **Objective**
  
  This course offers a practical introduction to the fundamentals of data analysis and R programming.

- **Content**
  
  Data analysis is fundamental for arriving at scientific conclusions and testing different hypotheses. This course offers a hands-on introduction to statistical analyses including: exploratory data analysis, testing differences in populations, p-values, power calculations, multiple testing, confounding, linear regression, maximum likelihood, model selection, and logistic regression; along with the fundamentals of R programming including markdown and data handling with the tidyverse.

- **Lecture notes**
  
  Lecture slides will be available.

- **Prerequisites / notice**
  
  Access to Rstudio with some markdown and tidyverse packages installed.

**636-0120-00L Introduction to Programming**

- **Objective**
  
  This is a voluntary programming course BEFORE the start of the semester (September 2022). It is addressed primarily at students of the MSc Biotechnology (and MSc CBB). Other students may send a request to participate to: student-admin@bsse.ethz.ch

- **Content**
  
  The goal of this course is to give students, who have no prior programming background, a solid introduction to algorithm development and its successive implementation in a programming language. For students with previously acquired programming skills, the course will serve as a reinforcement of key aspects of structured programming in addition to providing a well-rounded introduction to MATLAB, R and Python.

- **Prerequisites / notice**
  
  Available on course website (Moodle)

**636-0552-00L Metals in Biology**

- **Abstract**
  
  Analysis of key metalloenzymes including: Hydrolases, Oxygenases, Oxidases, Hydrogenases, Nitrogenase, Redox-proteins, Oxygen evolving complex, Photosystem II, Metal trafficking in cells, Metal homeostasis, DNA-binding proteins, Biomimetic chemistry, Artificial Metalloenzymes etc. Metals in medicine
Objective
Identify key features of metalloenzymes and enzyme mimics
Deduce and draw reasonable reaction mechanisms catalyzed by metalloenzymes
Understand the role of metalloenzymes in solving energy-related grand challenges
Design functional enzyme mimics
Critically analyze the structure and function of metalloproteins

636-0553-00L  Chemical Biology ■  W  3 credits  3G  external organisers
Abstract
The modern tools of chemical biology will be discussed and contextualized with a discussion of practical applications with those tools.

636-0551-00L  Supramolecular Chemistry ■  W  3 credits  2V  K. Tiefenbacher
Abstract
This course provides an introduction to supramolecular chemistry. Prior knowledge in supramolecular chemistry is not a prerequisite for this course.
Objective
After this course, the student is expected to understand and be able to apply the basics of supramolecular chemistry: host-guest interactions, host design, self-assembly and simple enzyme mimics.
Content
This course provides an introduction to supramolecular chemistry. Prior knowledge in supramolecular chemistry is not a prerequisite for this course. We will first cover the basic concepts of supramolecular chemistry: non-covalent interactions, host-guest chemistry, binding constant determination and binding strength. Subsequently, we will take a closer look at how to bind different species: cations, anions and neutral organic molecules. Towards the end of the semester, we will cover self-assembly processes and applications of supramolecular structures as simple enzyme mimetics.
Lecture notes
The lecture slides are provided online via ADAM. No additional literature is required. If additional information is desired, the book “Supramolecular Chemistry” by Jonathan W. Steed and Jerry L. Atwood (John Wiley & Sons) is recommended.

Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability
Recommended Science in Perspective (Type B) for D- BSSE
see Science in Perspective: Language Courses ETH/UZH

Biotechnology Master - Key for Type
O  Compulsory
W+  Eligible for credits and recommended
W  Eligible for credits
E-  Recommended, not eligible for credits
Z  Courses outside the curriculum
Dr  Suitable for doctorate

Key for Hours
V  lecture
G  lecture with exercise
U  exercise
S  seminar
K  colloquium
P  practical/laboratory course
A  independent project
D  diploma thesis
R  revision course / private study

ECTS  European Credit Transfer and Accumulation System
■  Special students and auditors need special permission from the lecturers.
Independently of the building industry, Module 1 initially provides information about the characteristics of digitalisation through its principles.

Module 5: New Business Modelle

We leave behind the negative images from the early days of automation. A gloomy and misanthropic image of automation - both a bliss and a curse. We get to know the positive sides and learn to apply them. How do we become a sustainable "Formula 1"?

How do the experiences of other industries help us? What can be derived from them? Why is BIM only a small part and why is the future of BIM not BIM?

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 3: Foundation of Automation

Module 3 we leave behind the negative images from the early days of automation. A gloomy and misanthropic image of automation - both a bliss and a curse. We get to know the positive sides and learn to apply them. How do we become a sustainable "Formula 1"?

What does it take to be able to work together in a digitally networked environment? How many "techie genes" are needed to work efficiently?

The module offers the opportunity to prepare for the voluntary buildingSMART Professional Certification.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 4: Foundation of Value Creation

"Highway to hell or highway to haven" - the question of a clear and simple roadmap is always at the heart of a digital transformation. "Value creation" is a central goal. Digitalisation is often seen as a strategy from the productivity gap. The fourth module shows how strategic goals can be developed in a roadmap and implemented in practice and how the individual shareholders and stakeholders participate.

We learn to consciously look at the topic of added value and digital transformation from different perspectives. Collision checking and quantity take-offs (QTO) are very useful. But they are only basics when it comes to real value creation.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Module 5: New Business Modelle

As a final module, new business models are discussed and explored. Examples will be used to explore patterns and interfaces and to analyse what is needed today and in the future for a successful and sustainable development of the sector. How can innovative ideas move us forward? What can we learn from design thinking? Why is it important for people to have useful and understandable measurable values? How do the 17 Sustainable Goals influence our industry?

We will analyse the topic on the basis of two concrete examples, familiarise ourselves with them and observe their further development as a result.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

The Term Paper is offered in spring semesters only.
### CAS ARC Digital - Key for Type

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<td>W+</td>
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### Key for Hours

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<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## CAS ARC in Project Leadership

### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>072-0201-00L</td>
<td>Module 1: Understanding of Roles</td>
<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<td>Only for CAS ARC in Project and MAS in Architecture, Real Estate, Construction.</td>
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<td>- Organisational forms</td>
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<tr>
<td>072-0202-00L</td>
<td>Module 2: Collaboration</td>
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<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<td>- Organisation charts</td>
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<td>- Project knowledge and process understanding</td>
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<td>- Structure of the project</td>
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<td>- Socio-economic viewpoint</td>
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<td>- Perception of demand</td>
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<td>072-0203-00L</td>
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<td>O</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<td>- Duties and tasks, liability</td>
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<td>- Working packages</td>
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<td>Module 4: Guiding/Steering/Leading</td>
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<td>- Leadership</td>
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<td>- Team performance</td>
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<td>- Motivation and conflict resolution</td>
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<td>072-0205-00L</td>
<td>Module 5: Project</td>
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<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<td></td>
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<td>- Decision making</td>
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<td>- Future perspectives</td>
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<td></td>
<td>- Micro and macro environment</td>
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<td>- Strength and flexibility</td>
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### Term Paper

*Offered in the Spring Semester.*
### CAS ARC in Project Leadership - Key for Type

<table>
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<tr>
<th>CAS Code</th>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
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### Key for Hours

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<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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**ECTS**

European Credit Transfer and Accumulation System

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### Core Courses

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>072-0301-00L</td>
<td>Module 1: Perception of Demand</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>S. Menz</td>
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<td>Must not be repeated in this semester. Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.</td>
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<tr>
<td></td>
<td>Key words: construction and real estate market, micro and macro environment</td>
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<td>Objective: In Module 1, by interpreting the snapshot of one’s own enterprise and opportunities and dangers to appreciate.</td>
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<td>Content: Introductory module «Enterprise» considers the role of organizations in the economic network of markets and their identity. It presents the peculiarities of planning offices as a service provider, shows different types of companies and discusses the business cycle from founding to succession planning. In addition, the branch-specific development of leadership and organizational models as well as the problem of access to international markets are examined. Accompanying the basics of a general business model for service companies are taught and key criteria defined.</td>
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<tr>
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<td>Literature recommendations at <a href="http://www.bauprozess.arch.ethz.ch">www.bauprozess.arch.ethz.ch</a> and <a href="http://www.kompetenz.arch.ethz.ch">www.kompetenz.arch.ethz.ch</a></td>
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<td>072-0302-00L</td>
<td>Module 2: State of the Art</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>S. Menz</td>
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<tr>
<td></td>
<td>Key words: Bauwerk Schweiz, new construction and renovation, economy Change in value, demolition / replacement, potential for compression</td>
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<td></td>
<td>Objective: Knowledge about type, extent and change of the building Switzerland and the main questions.</td>
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<td>Content: The importance of a life-cycle-oriented approach has arrived in the Swiss construction and real estate sector. Cumulative management costs can exceed the cost of construction after just a few years. In this module, a systematic consideration of the phases and processes in the life cycle of a property takes place. Study I explores various aspects of life-cycle planning and construction.</td>
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<td>072-0303-00L</td>
<td>Module 3: Economic Interest</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>S. Menz</td>
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<td>Must not be repeated in this semester. Only for CAS ARC in Real Estate Strategies urban-peri-urban and MAS in Architecture, Real Estate, Construction.</td>
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<td></td>
<td>Key words: intention development, realization operation The participants understand a property in the context of a life cycle</td>
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<td>072-0304-00L</td>
<td>Module 4: Course of Action</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>S. Menz</td>
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<td>Key words: maintenance, change, replacement Preservation of value, increase in value, destruction of value and replacement construction</td>
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<td>Objective: The various depths of intervention in dealing with a existing property and their effects are known.</td>
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<td>Content: The structure and nomenclature of the interventions in the stock are presented and models for the registration and calculation of the structural interventions are presented. It focuses specifically on ongoing maintenance, the periodic repair and planning of renewal cycles, as well as on structural interventions and value-enhancing measures. Based on the study II, the learning content is applied and various options for action in dealing with the building stock are evaluated.</td>
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<td>072-0305-00L</td>
<td>Module 5: Life Cycle and Resources</td>
<td>O</td>
<td>1</td>
<td>2G</td>
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<td></td>
<td>Key words: building fabric, material cycle Production and disposal / reusability of building fabric, energy flows, pollutants Building and breaking off is understood as an energy and material flow.</td>
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<td>Content: The total weight of all properties in Switzerland is estimated at around 1 billion tonnes. Every year around 10 million m3 of buildings are demolished and more than 60 million t of raw materials are used in new buildings. This module examines the cycle principle and its implications for selective decommissioning, disposal, landflling, recycling and reuse, as well as the importance of the gray matter energy of materials. Continuation, reuse, demolition / new construction - stakeholders, goals and conflicting goals</td>
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#### Term Paper
The term paper is offered in spring semester only.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 428 of 2416
| CAS ARC in Real Estate Strategies urban-peri-urban - Key for Type |
|------------------|--------------------------|
| **O** | Compulsory |
| **W** | Eligible for credits and recommended |
| **W** | Eligible for credits |
| **E-** | Recommended, not eligible for credits |
| **Z** | Courses outside the curriculum |
| **Dr** | Suitable for doctorate |

**Key for Hours**

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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
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<td>practical/laboratory course</td>
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<td>R</td>
<td>revision course / private study</td>
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**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Core Courses

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<th>Number</th>
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<td>Module 1: Market</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td></td>
<td>Key terms: Market, purpose and business model</td>
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<tr>
<td></td>
<td>The aim is to use a snapshot in time to interpret one’s own company and become able to assess opportunities and risks.</td>
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<td></td>
<td>The “company” module considers the role of organisations within the economic network of the markets and the nature of their identity. It presents the special aspects of planning offices as service providers, illustrates various types of company, and discusses companies’ life-cycle as they move from their founding to the period of planning for the succession. Both sector-specific development of management and organizational models and also the problems of obtaining access to international markets are also investigated. Alongside this, the foundations of a generally valid business model for service companies are described and key criteria are defined.</td>
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<td>072-0402-00L</td>
<td>Module 2: Acquisition</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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</tr>
<tr>
<td></td>
<td>Key terms: Competence, communication and network</td>
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<td></td>
<td>The aim is to become able to analyse and implement the processes and instruments used for acquisition in one’s own company.</td>
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<td>Acquisition represents a separate project in entrepreneurial activity, since all the activities involved in obtaining a commission fall under this term. The “acquisition” module focuses on imparting basic knowledge of networking and professional dialogue. Both of these tools require an assessment of one’s own situation with regard to competence, resources and customer relations. The conversation is a direct interaction: everyone involved is both an addressee and also basically an equal interlocutor. Networking can be learned: situational “small talk,” social competence and a healthy ability to communicate can be learned.</td>
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<td>072-0403-00L</td>
<td>Module 3: Marketing</td>
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<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td></td>
<td>Key terms: Planning, positioning and identity</td>
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<td></td>
<td>The aim is to become familiar with the tools used in marketing and able to use them in specific situations.</td>
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<td></td>
<td>Marketing means orienting company activities towards market demands. Communication between suppliers, clients and the competition plays the decisive role here. The “marketing” module illustrates the foundations of marketing planning for architects and engineers. The essential definitions are provided and the core tasks involved in marketing are described. On this basis, the way in which a marketing plan is developed is explained and strategic and operational marketing planning is described in detail. The topics of branding and the opportunities represented by press and public relations work for architects and planners round out the “marketing” module.</td>
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<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td></td>
<td>Key terms: Cost accounting, budgeting and controlling</td>
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<td>The aim is to become able to analyse one’s own company’s financial resources in detail, interpret key parameters for the current situation and use them.</td>
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<td></td>
<td>Financial management means achieving the target company output with costs that are as low as possible, and in the longer term to create secure asset and capital structures. The tasks involved in financial management in a planning office include establishing a well-structured accounting department, careful cost accounting, sound budgeting and an effective controlling system. On the basis of a practical financial structure for architecture and engineering offices, the “financial management” module presents the information needed to carry these tasks out in a professional and responsible way.</td>
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<td>Module 5: Digitalisation</td>
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<td>1</td>
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<td>A. Paulus, S. Menz</td>
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<td></td>
<td>Key terms: Strategy, potentials and digital planning</td>
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<td>Objective</td>
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<td>The aim is to become familiar with the current practical work involved in IT in planning companies and be able both to analyze the specific challenges it implies and also to infer one’s own prospects for development in this context. In addition, thought needs to be given to the way in which the value creation provided by digitalisation influences one’s own company.</td>
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<td></td>
<td>IT refers on the one hand to information and data processing in a company, and on the other to the hardware and software components needed for the purpose. This “information technology” module focuses on potential strategies for company management in the IT field. The focus is not on the use of any individual programme, but on taking conscious decisions for or against IT components in one’s own company in order to obtain helpful support in one’s everyday work. The strengths, weaknesses, opportunities and risk of this strategy suggest possible potentials.</td>
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<td>The participants will present their own theses on entrepreneurship and open them up for discussion in the plenary session.</td>
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### Term Paper

*Offered in the Spring Semester.*
### Key for Type

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### Key for Hours

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### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Advanced Materials and Processes

Module

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<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>O</td>
<td>12 credits</td>
<td>26A</td>
<td>Professors</td>
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Abstract
CAS AMaP participants are offered a MaP professor as a mentor together with whom they design their study plan along an individually-specified focus area in ‘Advanced Materials and Processes’. Building on the individual expertise, interests and needs of the participants, the customised CAS AMaP module consists of the elements (i) research project, (ii) courses and lectures, (iii) knowledge transfer.

Objective
The CAS AMaP module is fully customisable, building on the expertise of technical specialist professionals and aims at:
- training skills at the frontiers of the current state of research in Advanced Materials and Processes,
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

Content
Depending on individual interests and needs of the technical specialist professionals, the CAS AMaP module consists of the elements:
I. conducting a research project in the mentor’s group, addressing fundamental, development or applied problems, considering theoretical and/or experimental aspects,
II. individual schedule of courses and lectures with state-of-the-art knowledge, and
III. sharing of know-how in, e.g. seminars and interactive formats, thereby enhancing bidirectional knowledge transfer.

CAS in Advanced Materials and Processes - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
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<th>Courses outside the curriculum</th>
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Key for Hours

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<td>colloquium</td>
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ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
CAS in Applied Earth Sciences

► Modules Geo-Resources
The Module Geo-Resources runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS22 + HS22

<table>
<thead>
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<th>Number</th>
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<td>Autumn Course: Geothermal Usage of the Subsurface</td>
<td>W</td>
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<td>2G</td>
<td>M. O. Saar, P. Bayer, M. Brehme</td>
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</table>

Abstract
The block course focuses on shallow groundwater wells and ground heat exchangers, but also expands the spectrum to include geothermal energy and geostorage potential in Switzerland. The contributions address, among other things, the question of how, with increased use of geothermal resources, conflicts of use due to the growing number of uses can be dealt with.

Objective
The aim of the course is for participants to be able to describe the basic processes of geothermal use and to understand the regulatory framework. They will be able to assess the mutual influence of the uses and know possibilities to take these into account in strategic planning.

► Modules Geo-Contructions
The Module Geo-Contructions runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS23 + HS23

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<td>669-0202-00L</td>
<td>Autumn Course: Engineering Geology in Underground Constructions</td>
<td>W</td>
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<td>2G</td>
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► Modules Geo-Risks
The Module Geo-Risks runs over two semesters (FS and HS) and is offered every three years.

Takes place in FS24 + HS24

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<td>669-0302-00L</td>
<td>Autumn Course: Landslide Processes and Hazards</td>
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</table>

Abstract
The autumn course covers landslides in the broader sense, large slope movements and flowing mass movements in soil and rock. The course provides current and new knowledge needed for classification, determination of the relevant processes and estimation of the temporal behaviour of geological mass movements.

Objective
The participants learn which investigations and measurements can be used to improve the hazard analysis in a targeted manner, especially for more complex slope instabilities.

CAS in Applied Earth Sciences - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Required for the course and for the degree.</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for the course and highly recommended.</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Eligible for the course.</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>Recommended for the course, but not mandatory.</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>Courses outside the curriculum.</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>Suitable for the doctorate.</td>
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Key for Hours

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Applied Statistics

Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>447-0649-01L</td>
<td>Applied Statistical Regression I</td>
<td>O</td>
<td>4 credits</td>
<td>1V+1U</td>
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</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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</tr>
<tr>
<td></td>
<td>Only for DAS and CAS in Applied Statistics.</td>
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<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>Simple and multiple regression models, with emphasis on practical aspects and interpretation of results, analysis of residuals and model selection.</td>
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</tbody>
</table>

Further Courses

<table>
<thead>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-0649-02L</td>
<td>Applied Statistical Regression II</td>
<td>Z</td>
<td>2 credits</td>
<td>1V+1U</td>
<td>M. Mächler</td>
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<td>Does not take place this semester.</td>
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<td>Only for DAS and CAS in Applied Statistics.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Generalized linear models (GLMs) and basic ideas of more advanced regression models.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Understanding the concept and flexibility of generalized linear models and correct interpretation of the corresponding model outputs.</td>
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<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>447-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design I</td>
<td>O</td>
<td>3 credits</td>
<td>1V+1U</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td>Only for DAS and CAS in Applied Statistics.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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</table>

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<tr>
<td>447-0625-02L</td>
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<td>Z</td>
<td>3 credits</td>
<td>1V+1U</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td></td>
<td>Only for DAS and CAS in Applied Statistics.</td>
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<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>Random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze sophisticated experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<table>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>447-6221-00L</td>
<td>Nonparametric Regression</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>M. Mächler</td>
</tr>
<tr>
<td></td>
<td>Special Students &quot;University of Zurich (UZH)&quot; in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to <a href="mailto:registrar@ethz.ch">registrar@ethz.ch</a>. The Registrar's Office will then register you for the course.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>This course focuses on nonparametric estimation of probability densities and regression functions. These recent methods allow modelling without restrictive assumptions such as 'linear function'. These smoothing methods require a weight function and a smoothing parameter. Focus is on one dimension, higher dimensions and samples of curves are treated briefly. Exercises at the computer.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Knowledge on estimation of probability densities and regression functions via various statistical methods. Understanding of the choice of weight function and of the smoothing parameter, also done automatically. Practical application on data sets at the computer.</td>
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</tr>
<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-6257-00L</td>
<td>Repeated Measures</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>L. Meier</td>
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<td></td>
<td>Special Students &quot;University of Zurich (UZH)&quot; in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to <a href="mailto:registrar@ethz.ch">registrar@ethz.ch</a>. The Registrar's Office will then register you for the course.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Participants will gain the ability of recognizing repeated measures and to analyze them adequately. They will now know how to deal with pseudoreplicates.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>447-6289-00L</td>
<td>Sampling Surveys</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
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<tr>
<td></td>
<td>Special Students &quot;University of Zurich (UZH)&quot; in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to <a href="mailto:registrar@ethz.ch">registrar@ethz.ch</a>. The Registrar's Office will then register you for the course.</td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>The elements of a sample survey are explained. The most important classical sample designs (simple random sampling and stratified random sampling) with their estimation procedures and the use of auxiliary information including the Horvitz-Thompson estimator are introduced. Data preparation, non-response and its treatment, variance estimation and analysis of survey data is discussed.</td>
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</tbody>
</table>
In many research fields, spatially referenced data are collected. When analysing such data the focus is either on exploring their structure or on estimating parameters of spatial processes. The methods covered in this course allow for finding statistical procedures for more general models and to derive exact or approximate distributions of complicated estimators and test statistics.

**Objective**

- Knowledge of the Elements and the process of a sample survey. Understanding of the paradigm of random samples. Knowledge of simple random sampling and stratified random sampling and capability to apply the corresponding methods. Knowledge of further methods of sampling and estimation as well as data preparation and analysis.

**Lecture notes**

Introduction to the statistical methods of survey research

**447-6201-00L Nonparametric and Resampling Methods**

Does not take place this semester.

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**Abstract**

Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.

**Objective**

For classical parametric models there exist optimal statistical estimators and test statistics whose distributions can often be determined exactly. The methods covered in this course allow for finding statistical procedures for more general models and to derive exact or approximate distributions of complicated estimators and test statistics.

**Content**

Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.

**Prerequisites / notice**

This course is part of the programme for the certificate and diploma in Advanced Studies in Applied Statistics. It is given every second year in the winter semester break.

**447-6233-00L Spatial Statistics**

Does not take place this semester.

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

**Abstract**

In many research fields, spatially referenced data are collected. When analysing such data the focus is either on exploring their structure or on predicting spatial data. The course provides an introduction to geostatistical methods that are useful for such purposes.

**Objective**

The course will provide an overview of the basic concepts and stochastic models that are commonly used to model geostatistical data sets. In addition, the participants will learn a number of geostatistical techniques and acquire some familiarity with software that is useful for analysing spatial data.

**Content**

After an introductory discussion of the types of problems and the kind of data that arise in environmental research, an introduction into linear geostatistics (models: stationary random processes, modelling large-scale spatial patterns by regression, modelling autocorrelation by variogram; kriging: mean-square prediction of spatial data) will be taught. The lectures will be complemented by data analyses that the participants have to do themselves.

**Lecture notes**

Slides, descriptions of the problems for the data analyses and worked-out solutions to them will be provided.

**Literature**


**447-6273-00L Applied Bayesian Statistics**

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**Abstract**

Introduction to Bayesian statistics: basics of inference, computation with MCMC, linear model, logistic regression, Bayesian hierarchical models. Focus on applications and hands-on programming.

**Objective**

- understand the basics of Bayesian inference
- use R packages to run MCMC algorithms
- fit and understand Bayesian linear models
- introduction to hierarchical Bayesian models

**Prerequisites / notice**

This course is part of the programme for the certificate and diploma in Advanced Studies in Applied Statistics. It is given every second year in the winter semester break.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity to Diversity</td>
<td>Self-direction and Self-management</td>
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<td></td>
<td></td>
<td>Negotiation</td>
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**447-6273-00L Applied Bayesian Statistics**

<table>
<thead>
<tr>
<th>W</th>
<th>2 credits</th>
<th>2G</th>
<th>S. Robert</th>
</tr>
</thead>
</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 435 of 2416
We will learn how to describe business/scientific problems as probabilistic models, apply Bayes rules to draw inference from data, and use the probabilistic programming language STAN to obtain samples from posterior distributions. On the way we will fit linear models both for continuous and categorical outcomes, and explore techniques to deal with hierarchical structures in the data. There will be examples of applications from various fields: insurance, meteorology, marketing, etc.

**Literature**

- "Bayes Rules! An Introduction to Applied Bayesian Modeling", Alicia A. Johnson, Miles Q. Ott, Mine Dogucu - CRC Press 2022

**Prerequisites / notice**

- introductory statistics
- applied regression
- R

---

### 447-6191-00L Statistical Analysis of Financial Data

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

**Abstract**


**Objective**

Getting to know the typical properties of financial data and appropriate statistical models, incl. the corresponding functions in R.

### 447-6255-00L Analysis of High-Dimensional Data

Special Students "University of Zurich (UZH)" in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

**Abstract**

Block course on analysis of high-dimensional data with a focus on prediction and feature assessment.

**Objective**

The goal of this course is to gain a good understanding of the concepts discussed during the lecture and to apply the new methods on real data examples using the software "R". The topics covered in the lecture are:

1. Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularization
2. Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

**Content**

Course on Analysis of High-Dimensional Data with focus on Prediction and Feature Assessment.

**Lecture notes**

The block course is based on lecture notes (https://bookdown.org/staedler_n/highdimstats/).

**Literature**


**Prerequisites / notice**

The exercises are done exclusively with the (free, open source) software "R" (http://www.r-project.org). A final exam will also happen at the computers, using R (and your brains!).

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods and Technologies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Project Management</th>
<th>Communication</th>
<th>Cooperation and Teamwork</th>
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<th>Self-awareness and Self-reflection</th>
<th>Self-direction and Self-management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>assessed</td>
<td>not assessed</td>
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<tr>
<td>TECHNIQUES AND TECHNOLOGIES</td>
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<td>not assessed</td>
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</tbody>
</table>

**CAS in Applied Statistics - Key for Type**

<p>| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>V</td>
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<td>practical/laboratory course</td>
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<td>A</td>
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<tr>
<td>D</td>
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</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
CAS in Applied Information Technology

The CAS takes place in Autumn Semester only.

Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>265-0100-00L</td>
<td>Foundations of Programming</td>
<td>O</td>
<td>3</td>
<td>2A</td>
<td>L. E. Fässler</td>
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<tr>
<td></td>
<td>Only for CAS in Applied Information Technology and MAS in Applied Technology.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The initial module offers a practical introduction to some basic concepts and techniques for information processing as well as practical applications of them. The programming language are Python and SQL.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Students learn... - how to encode a problem into a program, test the program, and correct errors. - to understand and improve existing code. - to implement mathematical models as a simulation.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>No prior knowledge is required for this course. It is based on application-oriented learning. The students spend most of their time working through programming projects and discussing their results with teaching assistants. To learn the programming basics there are electronic tutorials available.</td>
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<tr>
<td>265-0101-00L</td>
<td>Data Science</td>
<td>O</td>
<td>3</td>
<td>3V</td>
<td>B. Gärtner</td>
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<td>Only for CAS in Applied Information Technology and MAS in Applied Technology.</td>
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<tr>
<td>Abstract</td>
<td>In this module, basic paradigms and techniques in working with data will be discussed, especially towards data security, managing data decentrally, and learning from data.</td>
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<tr>
<td>Objective</td>
<td>Participants learn about some important computer science concepts necessary for data science. They understand some of these concepts in detail and see the mathematics behind them.</td>
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<tr>
<td>Content</td>
<td>Participants will get an introduction to key computer science concepts underlying current and upcoming technology. The module in particular covers cryptography and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). Each topic will be discussed in two different ways: (i) a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments; (ii) a context part that addresses the challenges and limitations encountered in practical applications.</td>
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<tr>
<td>265-0102-00L</td>
<td>Data Modeling and Computer Vision</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>E. Konukoglu, C. Zhang</td>
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<td>Only for CAS in Applied Information Technology and MAS in Applied Technology.</td>
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<tr>
<td>Abstract</td>
<td>This module offers practical knowledge in visual information processing and human computer interactions.</td>
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<tr>
<td>Objective</td>
<td>Participants understand basic concepts of visual recognition and human-computer interaction systems.</td>
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<tr>
<td>Content</td>
<td>The first part of the module will cover basic theoretical knowledge on visual recognition systems of the last two decades, mostly focusing on the most recent advancements in deep learning and convolutional neural networks. The theoretical knowledge will be supported with practical sessions that will allow participants to gain hands-on experience with most commonly used tools and deepen their understanding of the key concepts. The second part provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.</td>
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<td>265-0103-00L</td>
<td>Applied Information Technology</td>
<td>O</td>
<td>3</td>
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<td>M. Brandis</td>
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<tr>
<td>Abstract</td>
<td>This integration module for CAS “Applied Information Technology” links technical understanding of technology with business strategy based on a set of case studies from practice.</td>
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<tr>
<td>Objective</td>
<td>Participants will learn how technology affects businesses and practical issues when using new technologies in incumbent organizations based on a set of case studies.</td>
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<tr>
<td>Content</td>
<td>Participants will explore how new information technologies change different aspects of a business, and learn how to evaluate specific risks, costs, and benefits of such technologies. The module will shed light on success factors and common pitfalls when implementing new technologies and respective business changes, and it will specifically address the communication between technical experts and business management. The studied cases are currently planned to focus on artificial intelligence, IoT including edge and cloud computing, blockchain and distributed ledger technologies, and cybersecurity and data protection regulations (subject to change).</td>
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CAS in Applied Information Technology - Key for Type

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<td>Recommended, not eligible for credits</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 438 of 2416
### Key for Hours

<table>
<thead>
<tr>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
The CAS takes place in Spring Semester only.

Start of the next course: FS 2023

<table>
<thead>
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<th>CAS in Applied Manufacturing Technology - Key for Type</th>
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<td>K</td>
<td>colloquium</td>
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ECTS

European Credit Transfer and Accumulation System

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CAS in Applied Technology in Energy

The CAS takes place in Spring Semester only.

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<td>E-</td>
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<td>Z</td>
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<tr>
<td>Dr</td>
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**Key for Hours**

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |
| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### CAS in Applied Technology: R&D and Innovation

The CAS takes place in Autumn Semester only.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>247-0200-00L</td>
<td>Fundamentals of R&amp;D and Innovation</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>U. Grossner, C. Ganz</td>
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<tr>
<td></td>
<td>Only for CAS in Applied Technology: R&amp;D and Innovation and MAS in Applied Technology.</td>
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<tr>
<td>Abstract</td>
<td>This course provides an introduction to research &amp; development, both as a general activity and as a dedicated function within a corporation. Participants will learn how to organize, conduct and manage individual R&amp;D projects as well as groups of projects. Special emphasis will be given to scientific and technical reporting.</td>
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<tr>
<td>Objective</td>
<td>The course provides the framework of organization, managing and reporting of R&amp;D projects and innovation initiatives.</td>
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<tr>
<td>Lecture notes</td>
<td>The module will be based on a self-study Polybook.</td>
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#### 247-0201-00L Innovation – What is and to what purpose do we need it?

Only for CAS in Applied Technology: R&D and Innovation and MAS in Applied Technology.

<table>
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<th>O 3 credits</th>
<th>2G</th>
<th>U. Grossner, C. Ganz</th>
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</table>

#### Objective

Innovation is more than a good idea: It involves bringing the idea to the market, resulting in a highly differentiating market position. Not only product, also ideas have a lifecycle, from conception through launch, scaling, maintenance, to phase out, and replacement by a new innovation. Each phase is facing particular challenges that will be explored.

#### 247-0202-00L R&D: The Engine of Innovation

Only for CAS in Applied Technology: R&D and Innovation and MAS in Applied Technology.

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<tr>
<th>O 3 credits</th>
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<th>U. Grossner, C. Ganz</th>
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</table>

#### Objective

The goal of this course is to develop the participants' ability to articulate a coherent plan for R&D activities linked to the business needs of a corporation, and to set the environment to enable an efficient R&D organization.

#### Content

In most organizations, the R&D organization is the one that delivers the innovation to be brought to the market. In this module, we investigate the inner working of the R&D organization by exploring roles and processes. Since R&D almost always starts with significant uncertainties and unsolved technical problems, governing R&D has to account for these unknowns. As R&D processes take time in which the market environment may change in ways other than predicted at the beginning of a project, external influences have to be continuously monitored as well to enable market success.

#### 247-0203-00L The Innovation Ecosystem

Only for CAS in Applied Technology: R&D and Innovation and MAS in Applied Technology.

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<th>O 3 credits</th>
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<th>U. Grossner, C. Ganz</th>
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</table>

#### Objective

This module wraps up the various aspects of innovation beyond the own organization.

#### Content

Successful innovation builds on a whole ecosystem of contributors: customer co-creation, university collaboration, strategic partnerships, or start-up investments are just a few examples of activities where other players may expedite the innovation process. Other aspects of the environment of innovation covers intellectual property strategy, or standardization and certification. In addition to successfully operating in the existing business ecosystem, innovation may transform it, or even create new ecosystems, with innovative business models.

In this module we will look at these various aspects of innovation beyond the own organization. This module will wrap up the CAS and put the material in context of the organization's environment.

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### CAS in Applied Technology: R&D and Innovation - Key for Type

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<td>W</td>
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### Key for Hours

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>268-0101-00L</td>
<td>Introduction to Information Security</td>
<td>O</td>
<td>5 credits</td>
<td>4G</td>
<td>P. Schaller, S. Matetic</td>
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<td><em>Only for CAS and DAS in Cyber Security.</em></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>In this course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students' understanding of the theory parts.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td></td>
<td>Graduates of the course know the technical foundations of information security and understand the difficulty and complexity involved when trying to build secure systems.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>In this new course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students' understanding of the theory parts.</td>
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<tr>
<td>268-0201-00L</td>
<td>Information Security Seminar and Project</td>
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<td>S. Matetic</td>
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<td><em>Only for CAS and DAS in Cyber Security.</em></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.</td>
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<td><strong>Objective</strong></td>
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<td>Participants have understood and presented a publication or report on a present topic in information security. By attending other participants presentations students get further introduced to additional current information security related topics/incidents.</td>
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<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.</td>
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<tr>
<td>268-0202-00L</td>
<td>Contemporary Topics in Cyber Security</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Matetic</td>
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<td><em>Only for CAS and DAS in Cyber Security.</em></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course is composed of various sub-modules related to Cyber Security taught by experts on the relevant fields.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Students are expected to see behind the curtain of current research and engineering activities related to Cyber Security. At the same time students are introduced to contemporary challenges in cyber security by renowned experts.</td>
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<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>The lectures cover contemporary aspects and challenges in Cyber Security. The goal is to present current fields of research/engineering and the latest results. By way of example, Cyber Security Policy is one of sub-modules presented by researchers of the Center for Security Studies at ETH. Besides faculty members of the computer science department, there will be guest lecturers from industry presenting Cyber Security related challenges in their field of activity.</td>
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<td>Will be announced during the course.</td>
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### CAS in Cyber Security - Key for Type

<table>
<thead>
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### Key for Hours

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### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
# CAS in Digital Health

## Modules

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<th>Number</th>
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<th>Hours</th>
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<tr>
<td>375-0003-00L</td>
<td>Designing a Digital Biomarker (Group Project 2) Only for CAS in Digital Health</td>
<td>O</td>
<td>4 credits</td>
<td>1G</td>
<td>F. Da Conceição Barata, F. Wortmann</td>
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### Abstract
The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

### Objective
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s ageing population and the ever-growing number of chronic patients. However, this premise is based on the application of information and communication technologies that allow us to monitor patient data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in a project.

The course has four core learning objectives. Students should:

- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

### Content
The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1. **Digital Biomarkers:** From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.
2. **Consumer-centric device data:** Today, vast amount of physiological, environmental, and behavioural observations can be collected with consumer centric devices. However, deriving meaningful information from this data is difficult. We will analyze strategies for extracting knowledge from those measurements.
3. **Methodology:** In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of machine learning domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.
4. **Applications:** Digital biomarkers are still an emerging subfield but given that longitudinal digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant applications will emerge in the near future. We will review and discuss current applications and challenges.

### Literature


### Prerequisites / notice
This module is assessed based on the participant's pass/fail status of the group project (including a presentation). The project involves the development of a procedure for collecting smartwatch data and applying analytical methods to predict sleep-related outcomes. Further details will be given at the beginning of the module.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>375-0004-00L</td>
<td>Designing a Just-in-time Adaptive Intervention (Group Project 3) Only for CAS in Digital Health</td>
<td>O</td>
<td>4 credits</td>
<td>2G</td>
<td>T. Kowatsch</td>
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</tbody>
</table>

### Abstract
Today, we face the challenge of chronic conditions. Personal coaching approaches are neither scalable nor financially sustainable. The question arises therefore to which degree Digital Health Interventions (DHIs) are appropriate to address this challenge. In this CAS module, students will design, implement and evaluate a DHI, esp. a just-in-time adaptive intervention.

### Objective
After this module, participants will be able to...

1. understand the importance of just-in-time adaptive interventions (JITAs), esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAs
3. discuss opportunities and challenges of JITAs

What are the implications and rationale behind the recent developments in the field of digital health?

Digital Health is the use of information and communication technology for the prevention and treatment of diseases in the everyday life of individuals. It is thus linked to topics such as digital health interventions, digital biomarkers, digital coaches and healthcare chatbots, telemedicine, mobile and wearable computing, self-tracking, personalized medicine, connected health, smart homes, or smart cars.

In the 20th century, healthcare systems specialized in acute care. In the 21st century, we now face the challenge of dealing with the specific characteristics of non-communicable diseases (NCDs). NCDs are now responsible for around 70% of all deaths worldwide and 85% of all deaths in Europe and are associated with an estimated economic loss of $7 trillion between 2011 and 2025. NCDs are characterized in particular by the fact that they require an intervention paradigm that focuses on prevention and lifestyle change. Lifestyle (e.g., diet, physical activity, tobacco, or alcohol consumption) can reduce the risk of suffering from a chronic condition or, if already present, can reduce its burden. A corresponding change in lifestyle is, however, only implemented by a fraction of those affected, partly because of missing or inadequate interventions or health literacy, partly due to socio-cultural influences. Individual personal coaching of these individuals is neither scalable nor financially sustainable.

To this end, the question arises on how to develop evidence-based digital health interventions (DHIs) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. At the intersection of health economics, behavioral medicine, information systems research, and computer science, this CAS module has the objective to help participants interested in the multi-disciplinary field of digital health to better understand the need, design, implementation, and assessment of DHIs, esp. just-in-time adaptive interventions (JITAIs).

After this module, participants will be able to...

1. understand the importance of JITAIs, esp. for the prevention of NCDs
2. understand the design, implementation and evaluation of smartphone-based and chatbot-delivered JITAIs
3. discuss opportunities and challenges of JITAIs

The CAS module is structured in two parts and follows the concept of a blended treatment consisting of live sessions and complementary online material. In the live sessions, participants will learn relevant topics. Complementary learning material (e.g., video clips), multiple-choice questions, and exercises are provided via the online learning platform.

In the second part, participants work in teams and will use their knowledge from the first part of the module to develop a smartphone-based and chatbot-delivered JITA with MobileCoach (www.mobile-coach.eu), an open-source software platform for the development of digital biomarker and digital health interventions. Each team will then present and discuss the resulting JITA and evaluation results with their colleagues who will provide peer reviews. Additional live coaching sessions are offered to support the teams with the design and evaluation of their JITAIs, and with the preparation of the final group project presentations.


Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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Social Competencies

<table>
<thead>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
<td>assessed</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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</table>

Negotiation | assessed |

Personal Competencies

| Adaptability and Flexibility     | assessed |
| Creative Thinking                | assessed |
| Critical Thinking                | assessed |
| Integrity and Work Ethics        | assessed |
| Self-awareness and Self-reflection | assessed |
| Self-direction and Self-management | assessed |
### CAS in Digital Health - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
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#### Key for Hours

<table>
<thead>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

### ECTS
- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 446 of 2416
### CAS in Entrepreneurial Leadership in Technology Ventures

**Start:** Every Autumn Semester and Spring Semester

**Duration:** 12 months. It is possible to join the programme at the beginning of each semester.

#### Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>373-0100-00L</td>
<td><strong>Entrepreneurial Strategies</strong>&lt;br&gt;Only for CAS in Entrepreneurial Leadership in Technology Ventures.</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>B. Clarysse</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This is the first knowledge module in the CAS ELTV. In this module we (1) introduce all participants to the CAS and ETH, (2) get to know in more detail the projects of the participants and how lean innovation plays a role, and (3) discuss important considerations of strategy formation in technology ventures.</td>
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<td>This module enables participants:</td>
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<td></td>
<td>- To understand and select from commercialization strategies available to them (e.g., licensing, partnering, and vertical integration) and respective business model choices</td>
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<td>- Assess and generate development options for key internal enabling factors such IP strategy and key resources and capabilities</td>
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<td>- Understand different market research and developments tools (lean start-up vs. technology broadcasting) and select appropriate methods and related KPIs</td>
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<td>This module focuses on elements of entrepreneurial strategy formation and implementation in nascent markets and/or industries. Participants will study commercial options available to them, e.g., technology broadcasting, licensing and partnering, and vertical integration, which is complemented by a practical view on IP strategy, driven by business strategy rather than arbitrary choices. The module also includes the introduction to lean innovation methods incl. agile product development methods and core tools of the lean startup approach.</td>
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<td><strong>Lecture notes</strong></td>
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<td>373-0101-00L</td>
<td><strong>Entrepreneurial Leadership and Teams</strong>&lt;br&gt;Only for CAS in Entrepreneurial Leadership in Technology Ventures.</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>J. Thiel</td>
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<td><strong>Abstract</strong></td>
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<td>This is the second knowledge module within the CAS ELTV. During this module, we will discuss important themes concerning entrepreneurial team formation and management and practice elements in interactive workshops.</td>
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<td>This module enables participants:</td>
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<td></td>
<td>- To understand key requirements for new venture leadership and how to build effective governance structures for the founding team</td>
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<td>- To select and implement approaches and methods to structure productive work relationships within an emerging firm.</td>
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<td>- To understand and build the organizational foundations for successful professionalizing of venture operations</td>
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<td>This module zooms in on the design and management of new venture teams in technology-based companies as well as the role of leadership in building successful venture teams. Key contents in this module comprise founder contracts, successful governance structures, and approaches to team performance management. This module also allows participants to understand requirements for venture leadership and professionalizing venture operations as well as building productive work relationship within their emerging firm.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>This module is only for CAS ELTV participants.</td>
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<td>373-0102-00L</td>
<td><strong>Entrepreneurial Marketing &amp; Sales</strong>&lt;br&gt;Only for CAS in Entrepreneurial Leadership in Technology Ventures.</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>M. Gruber, B. Clarysse</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>This is the third knowledge module within the CAS ELTV. During this module, we will discuss important themes concerning entrepreneurial team formation and management and practice elements in interactive workshops. The module will be extended by intermediary project review meetings.</td>
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<td></td>
<td>This module enables participants:</td>
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<td>- To understand key requirements and the respective markets</td>
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<td>- To practice and optimize successful communication with and towards existing and future customers (e.g., strategic selling, key account management, communication tools).</td>
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<td></td>
<td>- To understand and use different pricing techniques for technology products and services, both in B2C and B2B contexts,</td>
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<td>- To select appropriate strategies to build up effective sales channels and calculate and optimize respective funnel KPIs and assess the implications on the venture's business model and organization (e.g., lead management, funnel metrics, etc.)</td>
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<td>This module exposes participants to important customer development and market research strategies, with the goal to build competencies in several customer-facing activity domains of the growing venture. Key module themes span the pricing of technology products and services, both in B2C and B2B contexts, the effective build-up of sales channels and funnels, and the successful communication to existing as well as future customers.</td>
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<td><strong>Lecture notes</strong></td>
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<td>See Online Platform</td>
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<td>See Online Platform</td>
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<td>This module is only for CAS ELTV participants.</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>This module is the first part of the Business Coaching track of the CAS ELTV. The module offers a structured process through which participants develop their business projects. All projects receive regular guidance from a dedicated coach.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>This module enables participants:</td>
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<td></td>
<td>- To identify key unknowns and important progress measures for their respective business case and implement effective means and tools to further develop their business case</td>
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<td></td>
<td>- To understand the view of potential customers and implement their feedback to improve the business case</td>
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<td>- To effectively communicate and enroll other important venture constituents (mentors, advisors, employees, investors, etc.) in the venture</td>
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<td>This module focuses on the development needs of participants' business skills and competencies. In this module, experienced business coaches and startup mentors will interact regularly with the participants, offer guidance on how to strategize and implement compelling business cases, feedback on specific challenges, and participants' activities with the goal to strengthen the ability of the participant to garner needed resources for their undertakings.</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 447 of 2416
### Leadership Development I

**Module Code:** 373-0201-00L  
**Credit:** 1  
**Type:** O  
**Prerequisites:** This module is only for CAS ELTV participants.

**Abstract:**
This is the first module of the Leadership Development & Coaching track of the CAS ELTV. In this module, participants take stock of their current situation and goals and develop specific action points. This process is supported by experienced leadership coaches.

**Objective:**
This module enables participants:
- To identify current gaps in the personal management skills and competencies and develop meaningful goals and plans to fill those gaps
- To implement effective exercises and practices to improve the participants' leadership capacity
- To effectively communicate and manage key constituents, notably employees and key advisors in a venture project

**Content:**
This module focuses on the development needs of participants' leadership competencies. In this module, experienced leadership coaches will interact regularly with the participants, coach them along a personal development plan, and feedback participants on specific challenges and activities with the goal to strengthen the participants' leadership capability and people skills.

### Final Business Project Defense

**Module Code:** 373-0205-00L  
**Credit:** 1  
**Type:** O  
**Prerequisites:** This module is only for CAS ELTV participants.

**Abstract:**
This module focuses on the development needs for both the participants' presentation and resource mobilization skills. The participants are asked to bring all learnings from the CAS and defend in engaging manner their business projects. This defense is typically delivered in presence of external investors or venture stakeholders who will challenge the project and potentially offer future support.

**Objective:**
This module enables participants:
- To reflect upon and integrate important and relevant elements from the CAS into the venture project
- To practice effective business communication and venture pitching skills
- To receive and handle challenging feedback from important venture constituents.

**Content:**
This module focuses on the development needs for both the participants' presentation and resource mobilization skills. The participants are asked to bring all learnings from the CAS and defend in engaging manner their business projects. This defense is typically delivered in presence of external investors or venture stakeholders who will challenge the project and potentially offer future support.
The course aims at strengthening the capacity in portfolio management for VET, skills development and active labor market policies. It deals with basic issues and challenges of Vocational Education and Training (VET) in Developing Countries. In view of the many of school leavers VET has to place itself between the contradicting intensions of quality education and short-term training interventions.

**Objective**

The participants are able to:

- Assess project proposals and ongoing project regarding their relevance and suitability in the specific country context
- Explain strengths and weaknesses of the opposing approaches "dual apprenticeship" and "competency based training" as well as synergies and incompatibilities between the two
- Describe the competent use of tools currently applied in VET

**Content**

- Basic concepts of result-oriented project management
- Instruments and resources for project planning, including the elaboration of a "logframe matrix" and results chain
- Instruments and resources for project monitoring, and for the development of a monitoring system, including indicators to assess objectives achievement and steer the Project
- ‘Write’ and structure results-oriented Project reports

**Prerequisites / notice**

Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariate.

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**Module**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>865-0065-00L</td>
<td>VET between Poverty Alleviation and Economic Development</td>
<td>W</td>
<td>2</td>
<td>3G</td>
<td>K. Harttgen, F. Kehl, M. Maurer</td>
</tr>
</tbody>
</table>

**Abstract**

The course goes beyond awareness raising of personal cultural characteristics and recognizing cultural values within development projects. Together with the participants, we reflect on the situation-specific application of instruments for project planning and the development of a monitoring system, which makes it possible to adapt and steer projects.

**Objective**

The participants are able to:

- Assess project proposals and ongoing project regarding their relevance and suitability in the specific country context
- Explain strengths and weaknesses of the opposing approaches "dual apprenticeship" and "competency based training" as well as synergies and incompatibilities between the two
- Describe the competent use of tools currently applied in VET

**Content**

- Basic concepts of result-oriented project management
- Instruments and resources for project planning, including the elaboration of a "logframe matrix" and results chain
- Instruments and resources for project monitoring, and for the development of a monitoring system, including indicators to assess objectives achievement and steer the Project
- ‘Write’ and structure results-oriented Project reports

**Prerequisites / notice**

Students of the course must fulfill requirements specified on the homepage of NADEL.

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**Module**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>865-0064-00L</td>
<td>Decolonizing Aid</td>
<td>W</td>
<td>2</td>
<td>3G</td>
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</tr>
</tbody>
</table>

**Abstract**

The course is designed to increase awareness of how cultural perceptions and power structures have influenced society and our understanding of and practice in aid. It promotes alternatives to aid as linear and progressive Eurocentric narrative. The course draws on different theoretical perspectives and scrutinizes practical examples of aid interventions and similar initiatives.

**Objective**

The course goes beyond awareness raising of personal cultural characteristics and recognizing cultural values within development concepts. It unfolds traces of colonialism and power structures in day to day live and the aid industry. It promotes searching and initiating alternatives to aid as a Eurocentric narrative. Participants get familiar with different theoretical perspectives on decoloniality and scrutinize practical examples of aid interventions and similar initiatives.

**Content**

- Decolonialism key terms and concepts
- Conceptions of and alternatives to development (cooperation)
- Cultural (self-) awareness, diversity
- The role of culture in aid / development cooperation
- Implications of decoloniality for aid policy making and practice

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**Module**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>865-0070-00L</td>
<td>The Private Sector and Development Organizations: Building Successful Alliances</td>
<td>W</td>
<td>1</td>
<td>2G</td>
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</tbody>
</table>

**Abstract**

The course provides a deeper understanding of the methodological foundations of results-oriented planning and steering of development projects. Together with the participants, we reflect on the situation-specific application of instruments for project planning and the development of a monitoring system, which makes it possible to adapt and steer projects.

**Objective**

The course participants are able to describe the processes and concepts of project planning and monitoring using the correct technical terminology, to initiate an analysis of the initial situation, to elaborate a monitoring system, and to adaptively steer the implementation of projects.

**Content**

- Basic concepts of result-oriented project management
- Instruments and resources for project planning, including the elaboration of a "logframe matrix" and results chain
- Instruments and resources for project monitoring, and for the development of a monitoring system, including indicators to assess objectives achievement and steer the Project
- ‘Write’ and structure results-oriented Project reports

**Prerequisites / notice**

Students of the course must fulfill requirements specified on the homepage of NADEL.
students, as well as specialists with at least 24 months of practical experience in international cooperation. Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted "sur Dossier".

Registration only through the NADEL administration office.

Abstract

The following topics will be discussed: The political economy of the Corporate Social Responsibility discourse, voluntary governance regimes and development: theory of change and effectiveness of soft law approaches, PPPs: introducing concepts and taking stock of experience, analysis of private sector strategies from selected governance actors, engaging with the private sector.

This course seeks to increase the participants’ understanding of the multifaceted and dialectic relationships between civil society, governments and private sector. It equips participants with knowledge and tools required for a strategic interaction between private sector organizations and development agencies. The course enables participants to contribute effectively to policy debates on the role of private sector actors and development.

Students of the course must fulfill requirements specified on the homepage of NADEL.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credit</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>865-0021-00L</td>
<td>Fraud and Corruption: Prevent, Detect, Investigate, Sanction</td>
<td>W</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester. Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation. ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted. Registration only through the NADEL administration office.</td>
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</tbody>
</table>

Abstract

The course examines forms, causes and effects of fraud and corruption in developing countries. Participants receive an introduction to the main concepts and mechanisms of prevention, detection, investigation and sanctioning. By using practical examples, the course prepares participants for dealing with fraud and corruption related issues in the context of development projects.

Objective

Participants are able to describe and reflect on different forms, causes and effects of fraud and corruption in the context of development cooperation. Based on common concepts and mechanisms of the international community they are able to apply and differentiate prevention, detection, investigation and sanctioning of fraud.

CAS in Development and Cooperation - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E- Recommended, not eligible for credits</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z- Courses outside the curriculum</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr- Suitable for doctorate</td>
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Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P- practical/laboratory course</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A- independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D- diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R- revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Focus Courses and Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
<tr>
<td></td>
<td>Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection.</td>
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<td>After this course, students will:</td>
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<td>Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features. Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs. Be able to learn new languages more rapidly. Be aware of many subtle problems of object-oriented programming and know how to avoid them.</td>
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<td>Content</td>
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<td>The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different object-oriented languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.</td>
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<td>The topics discussed in the course include among others:</td>
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<td></td>
<td>The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)</td>
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<td>The key problems of single and multiple inheritance and how different languages address them</td>
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<td>Generic type systems, in particular, Java generics, C# generics, and C++ templates</td>
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<td>The situations in which object-oriented programming does not provide encapsulation, and how to avoid them</td>
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<td>The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing</td>
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<td>How to maintain the consistency of data structures</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0293-00L</td>
<td>Wireless Networking and Mobile Computing</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>S. Mangold</td>
</tr>
<tr>
<td></td>
<td>Course that gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.</td>
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<td>Objective</td>
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<td>The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.</td>
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<td>Content</td>
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<tr>
<td></td>
<td>Wireless Communication, Wi-Fi, Contact Tracking, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.</td>
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<td>Chapters:</td>
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<tr>
<td></td>
<td>1 Introduction</td>
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<td>2 Wireless Communication Basics</td>
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<td>3 IEEE 802.11 Wireless LAN (Wi-Fi)</td>
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<td>4 IEEE 802.15 Wireless PAN (ZigBee &amp; Bluetooth)</td>
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<td>5 Mobile Computing Algorithm Basics: Control and Game Theory</td>
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<td>6 Visible Light Communication</td>
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<td>7 Audio Communication</td>
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<td>8 Cellular Networking Basics (LTE, 5G, Internet-of-Things)</td>
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<td>9 Mobile Computing for Automated Medicine Delivery</td>
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<td>10 Cognitive Radio, Delay Tolerant Networking, Radio Spectrum Sharing</td>
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<td></td>
<td>Lecture notes</td>
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<td>The course material will be made available by the lecturer.</td>
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<td>(1) The course webpage (look for Stefan Mangold's site)</td>
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<td>(2) The Java 802 protocol emulator &quot;JEmula802&quot; from <a href="https://bitbucket.org/lfield/jemula802">https://bitbucket.org/lfield/jemula802</a></td>
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<td></td>
<td>Literature</td>
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<td></td>
<td>Prerequisites / notice</td>
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<td>Prerequisites:</td>
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<td>Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience</td>
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<td>Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).</td>
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</table>
Randomized Algorithms and Probabilistic Methods  

### Abstract
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

### Objective
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

### Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

### Lecture notes
Yes.

### Literature
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include:

* Security requirements & risk analysis,
* System modeling and model-based development methods,
* Implementation-level security, and
* Evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites /
notice
Prerequisite: Class on Information Security

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 453 of 2416
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
- Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-0543-01L Computer Graphics

Abstract

This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

Objective

The course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

Content

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

No lecture notes, but slides will be made available on the course webpage.

Literature

Books:
- High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
- Multiple view geometry in computer vision
- Physically Based Rendering: From Theory to Implementation

Prerequisites / notice

Prerequisites:
- Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.
- The programming assignments will be in C++. This will not be taught in the class.

252-0546-00L Physically-Based Simulation in Computer Graphics

Abstract

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Objective

The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Content

The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

Prerequisites / notice

Prerequisites:
- Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

252-1411-00L Security of Wireless Networks

Abstract

Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.
After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.

**Objective**


**Content**

The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains.

In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

**Prerequisites / notice**

Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

**Lecture notes**

yes

**Literature**


S. Shinde


Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing 3V+2U+3A

2V+2U+1A

The course is split into 3 parts:

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


Relevant topics are covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as algorithms.


263-2400-00L Reliable and Trustworthy Artificial Intelligence  W  6 credits  2V+2U+1A  M. Vechev

Objective

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

Content

The course is split into 3 parts:

Robustness in Deep Learning

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


Relevant topics are covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Fostered competencies

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Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as algorithms.

263-2800-00L Design of Parallel and High-Performance Computing  W  9 credits  3V+2U+3A  T. Hoefler, M. Püschel

Number of participants limited to 125.

Objective

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3010-00L Big Data  W  10 credits  3V+2U+4A  G. Fourny

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts. "Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them involves a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of
the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large
clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad
range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, …)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study
administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a
series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for
Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data
representations.

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as
computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning
and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work
and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites / Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-3845-00L</td>
<td>Data Management Systems</td>
<td>W 8</td>
<td>G. Alonso</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.</td>
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<tr>
<td>Objective</td>
<td>The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.</td>
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<tr>
<td>Content</td>
<td>The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.</td>
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<tr>
<td>Literature</td>
<td>The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories assessed Techniques and Technologies assessed</td>
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<td>263-3850-00L</td>
<td>Informal Methods</td>
<td>W 5</td>
<td>D. Cock</td>
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<tr>
<td>Abstract</td>
<td>Formal methods are increasingly a key part of the methodological toolkit of systems programmers - those writing operating systems, databases, and distributed systems. This course is about how to apply concepts, techniques, and principles from formal methods to such software systems, and how to get into the habit of thinking formally about systems design even when writing low-level C code.</td>
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<td>Objective</td>
<td>This course is about equipping students whose focus is systems with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers. By the end of the course, students should be able to seamlessly integrate basic concepts form formal methods into how they conceive, design, implement, reason about, and debug computer systems. The goal is not to provide a comprehensive introduction to formal methods - this is well covered by other courses in the department. Instead, it is intended to provide students in computer systems (who may or may not have existing background knowledge of formal methods) with a basis for applying formal methods in their work.</td>
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<td>Content</td>
<td>This course does not assume prior knowledge of formal methods, and will start with a quick review of topics such static vs. dynamic reasoning, variants and invariants, program algebra and refinement, etc. However, it is strongly recommended that students have already taken one of the introductory formal methods course at ETH (or equivalents elsewhere) before taking this course - the emphasis is on reinforcing these concepts by applying them, not to teach them from scratch. Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified seL4 microkernel will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).</td>
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<tr>
<td>263-4640-00L</td>
<td>Network Security</td>
<td>W 8</td>
<td>A. Perrig, S. Frei, M. Legner, K. Paterson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.</td>
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<td>Objective</td>
<td>- Students are familiar with fundamental network-security concepts. - Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures. - Students can identify and assess vulnerabilities in software systems and network protocols. - Students have an in-depth understanding of a range of important state-of-the-art security technologies. - Students can implement network-security protocols based on cryptographic libraries.</td>
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The course will cover topics spanning four broad themes with a focus on the first two themes:

1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in 252-0064-00L or 227-0120-00L.

Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

263-5005-00L Artificial Intelligence in Education W 3 credits 1V+0.5U M. Sachan, T. Sinha

Abstract
Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.

Objective
The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

Content
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture notes
Lecture slides will be made available at the course Web site.

Literature
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

Prerequisites / notice
There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

263-5210-00L Probabilistic Artificial Intelligence W 8 credits 3V+2U+2A A. Krause

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

263-5255-00L Foundations of Reinforcement Learning W 5 credits 2V+2A N. He

Does not take place this semester.

Number of participants limited to 190.

The course will be offered again in FS23.

Abstract
Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control.
Objective
This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to:
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover "new" applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content
- Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes
Lecture notes will be posted on Moodle.

Literature
- Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
- Algorithms for Reinforcement Learning, Csaba Czejpészvári.

Prerequisites / notice
- Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-533-00L Philosophy of Language and Computation

Objective
Understand the philosophical underpinnings of language-based artificial intelligence.

Abstract
This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data.

Content
- The first semester we will discuss structuralism, recursive structure and logic, and in the second semester we will focus on language games, information and pragmatics. The modules will be four weeks long. During the first two weeks of a module, we will read and discuss original texts and supplementary criticism. During the second two weeks, we will read recent NLP papers and discuss how the authors of those works are building on philosophical insights into our conception of language—perhaps implicitly or unwittingly.

Literature
- Introduction to Computer Graphics, 3D Computer Vision. This will be used as a reference text and also as a basis for the exercises.
- The course is typically offered twice a year, one in the first semester of the academic year, and the other in the second semester. The second semester does not depend on the first, and thus either half may be taken independently.

Prerequisites / notice
- Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, machine learning.

636-0007-00L Computational Systems Biology

Objective
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content
- Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis, and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

Literature
- Systems and Synthetic Biology, 2nd edition, Guido Meier.

Prerequisites / notice
- Students should have a solid background in mathematics, particularly linear algebra, probability theory, and optimization.
- Good programming skills (C, C++, Java etc.)
- Computer graphics/vision experience: Students should have taken a course in computer science that covers computer graphics and vision.

423-5902-00L Computer Vision

Objective
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Content
- Computer models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structuring from motion, Tracking, Object recognition, Object category recognition.

Prerequisites / notice
- Good programming skills (C / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken a course in computer science that covers computer graphics and vision.

623-5905-00L Mixed Reality

Objective
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

Content
- The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics; 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course is to develop project ideas and student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice
- Prerequisites include:
  - Good programming skills (C / C++ / Java etc.)
  - Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

636-0007-00L Computational Systems Biology

Objective
Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, interpretation).

Content
- Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis, and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

Prerequisites / notice
- Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, machine learning.

423-5905-00L Mixed Reality

Objective
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Content
- Computer models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structuring from motion, Tracking, Object recognition, Object category recognition.

Prerequisites / notice
- Good programming skills (C / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 460 of 2416
The main goals of the seminar are the independent study of scientific literature and assessment of its contributions as well as learning and applying these methods in practice. The seminar covers various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.

The seminar is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
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- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
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- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
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- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover security protocols: models, specification & verification, trust management, access control and non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, and key-management for sensor networks. The publications to be presented will be announced on the seminar home page at least one week before the first session. The seminar covers various topics in information security, including network security, cryptography and security protocols. The participants are expected to read a scientific paper and present it in a 35-40 min talk. At the beginning of the semester a short introduction to presentation techniques will be given.

Abstract
In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover statistical models in computer vision, graphical models and machine learning. The seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics. The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve presentations and critical analysis skills. The students will learn how to structure a scientific presentation in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

Objective
Each student will be asked to study some papers from the recent software engineering literature and review them. This is an exercise in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

Content
This seminar covers advanced topics in computer vision by reading and presenting classic and state-of-the-art papers. Each time the course is offered, a collection of research papers are selected covering topics such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction and others. Each student presents one paper to the class and leads a discussion about the paper and related topics.

Literature
The papers will be presented in the first session of the seminar.

Number of participants limited to 40.

Objective
The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

Abstract
The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

Literature
The papers will be presented in the first session of the seminar.

Number of participants limited to 24.

Abstract
In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover statistical models in computer vision, graphical models and machine learning. The seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics. The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve presentations and critical analysis skills. The students will learn how to structure a scientific presentation in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

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Abstract
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Content
This seminar covers advanced topics in computer vision by reading and presenting classic and state-of-the-art papers. Each time the course is offered, a collection of research papers are selected covering topics such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction and others. Each student presents one paper to the class and leads a discussion about the paper and related topics.

Literature
The papers will be presented in the first session of the seminar.

Number of participants limited to 22.

Abstract
This seminar is an opportunity to become familiar with current research in software engineering and more generally with the methods and challenges of scientific research.

Objective
Each student will be asked to study some papers from the recent software engineering literature and review them. This is an exercise in critical review and analysis. Active participation is required (a presentation of a paper as well as participation in discussions).

Content
This seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Objective
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

Literature
The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.
The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

Students taking this seminar should have the necessary background in systems and low level programming.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>SE</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-3713-00L</td>
<td>Advanced Topics in Human-Centric Computer Vision</td>
<td>2</td>
<td>2S</td>
<td>O. Hilliges</td>
</tr>
<tr>
<td></td>
<td>The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<tr>
<td></td>
<td>In this seminar we will discuss state-of-the-art literature on human-centric computer vision topics including but not limited to human pose estimation, hand and eye-gaze estimation as well as generative modeling of detailed human activities.</td>
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<td></td>
<td>The learning objective is to analyze selected research papers published at top computer vision and machine learning venues. A key focus will be placed on identifying and discussing open problems and novel solutions in this space. The seminar will achieve this via several components: reading papers, technical presentations, writing analysis and critique summaries, class discussions, and exploration of potential research topics.</td>
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<td></td>
<td>The goal of the seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and oral presentation skills. The seminar will have a different structure from regular seminars to encourage more discussion and a deeper learning experience.</td>
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<td></td>
<td>We will treat papers as case studies and discuss them in-depth in the seminar. Once per semester, every student will have to take one of the following roles:</td>
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<td>Presenter: Give a presentation about the paper that you read in depth.</td>
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<td>Reviewer: Perform a critical review of the paper.</td>
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<td></td>
<td>Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.</td>
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<td>All other students: read the paper and submit questions they have about the paper before the presentation.</td>
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<td></td>
<td>The topic covered in the seminar is related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.</td>
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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>SE</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5702-00L</td>
<td>Seminar on Digital Humans</td>
<td>2</td>
<td>2S</td>
<td>M. Gross, B. Solenthaler, S. Tang, R. Wampfler</td>
</tr>
<tr>
<td></td>
<td>The deadline for deregistering expires at the end of the third week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<td></td>
<td>This seminar covers advanced topics in digital humans with a focus on the latest research results. Topics include estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. A collection of research papers is selected.</td>
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<td></td>
<td>The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills.</td>
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<tr>
<td></td>
<td>This seminar covers advanced topics in digital humans including both seminal research papers as well as the latest research results. A collection of research papers are selected covering topics such as estimating human pose and motion from images, human motion synthesis, learning-based human avatar creation, learning neural implicit representations for humans, modeling, animations, artificial intelligence for digital characters, and others. Each student presents one paper to the class and leads a discussion about the paper. All students read the papers and participate in the discussion.</td>
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<td></td>
<td>Individual research papers are selected each term. See <a href="https://vlg.inf.ethz.ch/">https://vlg.inf.ethz.ch/</a> and <a href="http://graphics.ethz.ch/">http://graphics.ethz.ch/</a> for example papers.</td>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>SE</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5100-00L</td>
<td>Topics in Medical Machine Learning</td>
<td>2</td>
<td>2S</td>
<td>G. Rätsch, J. Vogt</td>
</tr>
<tr>
<td></td>
<td>The deadline for deregistering expires at the end of the fourth week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<tr>
<td></td>
<td>This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold a presentation and lead the subsequent discussion.</td>
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<td>Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.</td>
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<tr>
<td></td>
<td>The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.</td>
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<thead>
<tr>
<th>CAS in Computer Science - Key for Type</th>
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<tbody>
<tr>
<td>O</td>
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<td>W+</td>
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<td>W</td>
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<tr>
<td>Key for Hours</td>
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<td>A</td>
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<td>D</td>
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<td>R</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in International Policy and Advocacy

The CAS is offered once per year in the spring semester.
Course duration: 1 Semester, part-time

More information at: www.sspg.ethz.ch/en

<table>
<thead>
<tr>
<th>CAS in International Policy and Advocacy - Key for Type</th>
<th>Key for Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>O Compulsory</td>
<td>E- Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+ Eligible for credits and recommended</td>
<td>Z Courses outside the curriculum</td>
</tr>
<tr>
<td>W Eligible for credits</td>
<td>Dr Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

- V lecture
- G lecture with exercise
- U exercise
- S seminar
- K colloquium
- P practical/laboratory course
- A independent project
- D diploma thesis
- R revision course / private study

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**CAS in Future Transport Systems: New Business Models**

The "CAS in Future Transport Systems: New Business Models" takes place only in Spring Semester

Start of the next course: Spring Semester 2023
Course duration: Six months part time
Periodicity: yearly


### CAS in Future Transport Systems: New Business Models - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
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<tr>
<td>Z</td>
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<tr>
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<td>Suitable for doctorate</td>
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### Key for Hours

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<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
- European Credit Transfer and Accumulation System

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### Major Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>166-0100-00L</td>
<td>Transport Systems: Dynamics and Future Development</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Erath Rusterholtz, P. J. de Haan van der Weg</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Interrelationships and dynamic change and the impact of these on mobility and transportation are being investigated in this module. The module addresses desirable future development of urban transport systems in Switzerland by covering and critically examining authentic, existing transport scenarios (e.g. ARE) in an exercise setting which deploys backcasting.</td>
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<td></td>
<td>Objective</td>
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<td></td>
<td>Participants</td>
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<tr>
<td></td>
<td>- understand the complexity of the transport system status quo as a whole, and are able to describe it qualitatively and create an operational and/or working context (K1).</td>
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<td>- understand the development of transport systems and future transport scenarios over time, and can infer objectives from the latter (K2).</td>
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<td>- understand the dynamics between spacial quality and mobility behavior and can evaluate how measures to promote active mobility can contribute to a more sustainable transport system (K3).</td>
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<td>- understand how digitalisation drives new mobility services (mobility as a service), and are able to qualitatively estimate the changes these bring to transport systems as a whole (K4).</td>
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<td>- are able to pinpoint the challenges and potential of the transition to autonomous transport forms (K5).</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>- Deepen understanding of complex transport systems and their dynamics past – status quo – future</td>
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<td></td>
<td>- Consolidate a foundation in the dynamics of transport systems: elements and their interrelationships</td>
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<tr>
<td></td>
<td>- Overview and selection of methods/approaches for the development and analysis of scenarios</td>
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<td></td>
<td>- Future perspectives (ARE), target scenarios</td>
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<td></td>
<td>- Transformation and change in systems</td>
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<td>- Transport policy and the potential of regulation</td>
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<td>- Excursion: “Infrastructure to support active mobility: Bike capital Bern”</td>
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<td>Methods selected</td>
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<td></td>
<td>- System analysis, scenario analysis, foresight, indicators for sustainable mobility, Case studies, reading and discussion of thesis papers and scientific publications</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<td>Distributed at start of module</td>
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<tr>
<td></td>
<td>Literature</td>
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<td></td>
<td>Distributed at start of module</td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td>Announced to students of the of the MAS / CAS at the beginning of the term</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>166-0101-00L</td>
<td>Development and Assessment of Transport Scenarios</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>A. Erath Rusterholtz</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>This module familiarises participants with current methods of developing and evaluating transport scenarios. These include analysis of the interrelationship of space and traffic; traffic modelling methods; and evaluation according to economic and planning criteria.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Participants</td>
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<td>- are familiar with suitable methods for developing transport scenarios and how to analyse and evaluate them. In particular, they know how to address the challenges of evaluating future forms of transport;</td>
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<td>- are able to select a suitable method and determine an evaluation concept with relation to a specific problem.</td>
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<tr>
<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>- Methodological foundations of traffic modelling (44-level model, activity-based model, agent-based simulation)</td>
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<td></td>
<td>- Design and evaluation of transport scenarios using MATSim (traffic simulation) with a focus on transport with autonomous vehicles</td>
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<td></td>
<td>- Interrelationship of space and traffic (accessibility measurement, settlement density and mixed usage) and what to consider in designing and evaluating transport scenarios</td>
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<td>- Approaches to evaluation of traffic scenarios (cost-benefit analyses and their foundations, methodological limits), analysis of effects taking into account user group and space type</td>
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<td></td>
<td>- Ecobalancing with Life Cycle Assessment (LCA) in addressing passenger and goods transport issues</td>
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<td></td>
<td>- Development of case studies on shared transport and mobility with an activity- and agent-based transport simulation model</td>
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<td>Methods</td>
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<td>- Aggregated and activity-based transport demand models</td>
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<td>- Agent-based simulation</td>
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<td>- Cost-benefit analysis</td>
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<td>- Accessibility analysis</td>
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<td>Case studies</td>
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<td>- Shared mobility</td>
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<td>- Autonomous mobility</td>
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<td></td>
<td>- Densified settlement development and slow forms of mobility</td>
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<td>Foundations for the Design of Transport System</td>
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<td>2G</td>
<td>J. Schippl</td>
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<td>Innovation and Change Processes</td>
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</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 467 of 2416
### Objective
Participants are able...
- to understand the economic and social-science fundamentals of innovation and change processes in the area of transportation;
- to analyse the foundations, opportunities and challenges of disruption in mobility systems;
- to set this concepts and frameworks in context to pathways towards more sustainable mobility;
- and to set these concepts and frameworks constructively in context to their own work practice.

### Content
In this module, innovation, change and transitions in transportation systems on different levels are discussed from different complementary perspectives. Both economic and social science approaches to the analysis, anticipation and governance of innovation processes are presented, discussed and applied to current issues. Topics are:
- Key figures, development and trends in air and shipping traffic.
- Innovation as an economic discovery process, measuring innovation.
- Emerging trends as new opportunities for innovation.
- Innovation today in the transportation/mobility system: theoretical basis and concrete examples.
- Transition of socio-technical systems, co-evolution of technical and societal dynamics.
- The relevance of social acceptance and ethical aspects for innovations in mobility.

### Lecture notes
Distributed at start of module

### Literature
Distributed at start of module

### Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

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<table>
<thead>
<tr>
<th>166-0103-00L</th>
<th>System Aspects of Air and Shipping Traffic</th>
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<tr>
<td><strong>Number</strong></td>
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<tr>
<td><strong>Title</strong></td>
<td>Only for MAS in Future Transport Systems and CAS in Systemic Aspects of Future Transport.</td>
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<tr>
<td><strong>Hours</strong></td>
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<tr>
<td><strong>Lecturers</strong></td>
<td>M. A. Streicher-Porte</td>
</tr>
</tbody>
</table>

**Abstract**
Air and shipping traffic cover a substantial part of human mobility, air traffic in passenger as well as freight transport, shipping mainly in freight transport. Students gain an overview, limit modes of mobility and learn to classify air and shipping traffic in the overall system of mobility.

**Objective**
Participants
- know the fundamental differences between air, shipping traffic compared to motorized individual transport and public transport.
- are able to deduce differences between air and shipping traffic.
- know the possibilities and limits as well as pros and cons of different valuation methods used for air and shipping transport.
- develop ideas for suitable indicators to evaluate scenarios in air and shipping traffic.

**Content**
- Key figures, development and trends in air and shipping traffic.
- Potentials for holistic improvement in air and shipping traffic.
- Life Cycle Assessment (LCA) for questions in air and shipping traffic.
- Overview on technologies and their potentials to improve sustainability in air and shipping transport.
- Berechnung und Interpretation von Kennzahlen.

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### CAS Thesis

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<th>Lecturers</th>
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<td>166-0190-00L</td>
<td>CAS Thesis on System Aspects ■</td>
<td>O</td>
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<td>5D</td>
<td>M. A. Streicher-Porte</td>
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**Abstract**
The participants deal with a current problem from the topics of CAS System Aspects.

**Objective**
- Deal with a specific problem from the CAS System Aspects subject area.
- Deepen selected content from module independently
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

**Content**
In der CAS-Arbeit zeigen die Studierenden, dass sie in der Lage sind, eine fundiert aufbereitete Auseinandersetzung mit technischen und nicht-technischen Entwicklungen im Mobilitätsystem und deren mögliche Auswirkungen auf das Schweizer Verkehrssystem oder auf Teilbereiche desselben anzufertigen.

Die Teilnehmenden setzen sich dabei aktiv mit aktuellen und/oder zukünftig erwarteten Entwicklungen im Mobilitätssektor auseinander, übersetzen mögliche Entwicklungen in verkehrliche Parameter (=Zukunft der Mobilität), greifen auf Lerninhalte des Studiums zurück; entwickeln ausgewählte Themen selbständig weiter (bzw. im Rahmen einer Arbeitsgruppe) und setzen sich mit der Relevanz für die Praxis auseinander (Relevanz für Stakeholdergruppen wie z.B. politische Entscheidungsträger, Verkehrsunternehmen, Industrie, Umweltverbände, Energieversorger sowie auch andere gesellschaftliche Gruppen, z.B. für Menschen im Rentenalter).

**Lecture notes**
Distributed at start of module.

**Literature**
Distributed at start of module.

**Prerequisites / notice**
Announced to students of the of the MAS / CAS at the beginning of the term.

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### CAS in Future Transport Systems: Systemic Aspects of Future Transport - Key for Type

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**Key for Hours**

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<td>colloquium</td>
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**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 468 of 2416
### Major Courses

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<tr>
<td>166-0200-00L</td>
<td>Technology Potential: Powertrain, Systems and Energy Carriers</td>
<td>O</td>
<td>3.5 credits</td>
<td>3G</td>
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<td><strong>Abstract</strong></td>
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<td>The module provides a foundation in the current situation and short- and middle-term development directions of powertrain and automotive engineering in the context of passenger &amp; goods transport. Corresponding energy sources and resulting consequences for the energy system are addressed. Participants will be enabled to identify potentials of these technologies and apply them to concrete problems.</td>
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<td>Familiarity with conventional and alternative powertrain and automotive systems for future sustainable mobility, and the ability to identify and deploy their potential to address concrete problems.</td>
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<td>Drive component efficiency rates and core fields</td>
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<td>Drive and non-drive energy flow / Vehicle <em>driving resistance</em></td>
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<td>Energy chains (operating power only) and CO2 emissions to primary energy</td>
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<tr>
<td>166-0201-00L</td>
<td>Potential of Spatial Information- and Communication Technologies</td>
<td>O</td>
<td>3 credits</td>
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<td><strong>Abstract</strong></td>
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<td>The digital revolution, spatial information and communication systems in particular, have a significant influence on the development of new transport systems. Participants acquire an in-depth understanding of the functionality and application potential of spatial information systems and services and of communication technologies for deployment in future transport systems and applications.</td>
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<td></td>
<td>Familiarity with information and communication technologies (ICT) and spatial information technologies, and the ability to identify and utilise their potential to address concrete problems.</td>
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<td></td>
<td>Functionality and application of geographic information systems (GIS) to represent and analyse transport systems (acquire, model, analyse and visualise geodata)</td>
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<td>Deployment potentials of GIS and ICT for efficient transport solutions (tangible, non-tangible)</td>
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<td>Functionality and application of mobile spatial information technologies in future transport systems</td>
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<td>Methods of spatiotemporal analysis and geodata analysis</td>
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<td>Technical aspects of information and communication technologies (ICT)</td>
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<td></td>
<td>Modelling, simulation and assessment of traffic behaviour</td>
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<td>Basics of autonomous driving</td>
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<td>Legal aspects of geodata</td>
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<td>Applications: Traffic behaviour in Switzerland; location based services for energy-efficient behaviour; GIS for the Zurich traffic system (multimodal)</td>
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<tr>
<td>166-0202-00L</td>
<td>Integrated Assessment of Technologies and Transport Systems</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The module provides a solid introduction to integrated technology assessment with regard to economic, ecological and social criteria. It introduces life cycle assessment (LCA), cost assessment, risk assessment and multi-criteria decision analysis. It also presents scenario analyses based upon energy-economic models which explicitly represent transport and energy-supply technologies.</td>
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<td><strong>Objective</strong></td>
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<td>An overview of suitable methods for analysing and evaluating technical systems (transport systems) and the ability to choose among them to address concrete problems.</td>
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</table>
Content

(1) Introduction to and overview of integrated assessment
- Current status of transport in Switzerland and internationally
- Scope and goals of integrated assessment
- Sustainability: concept and practical implementation via criteria and indicators
- Overview of concepts and implementation methods

(2) Selected methods for assessing transport technologies and their application to current and future options
- Ecobalance / life cycle assessment (LCA)
- Location-specific assessment of health hazards and environmental pollution
- Risk analysis
- Internal cost assessment
- External cost assessment

(3) Integrated assessment of transport technologies
- Overall costs (internal and external)
- Multi-criteria analysis

(4) Analysis of transport scenarios
- Scenarios, influencing factors, policy and sustainability
- Approaches to scenario modelling
- Global mobility scenarios: examples
- Transport scenarios for Switzerland using energy system models

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

166-0203-00L Energy Carrier for the Mobility of the Future ■ O 3.5 credits 3G
Does not take place this semester.

Abstract
The module includes the supply of the road mobility of the future with renewable energy. The generation, transport, processing, transfer of energy to the vehicles (refueling, charging) and the energetic evaluation are presented. Electricity, hydrogen, biogenic and synthetic fuels are considered.

Objective
The aim of the module is a detailed energetic and technical understanding of the supply of road vehicles with renewable energy. Graduates know the primary energy production as well as the end energy processing of the different energy carrier concepts. In addition, they know the legal CO2 requirements for vehicle registration and are able to qualitatively assess the impact on the Swiss energy system.

Content
- The energy system of the future; biogenic and electric renewable primary energy
- End energy processing
- Transfer from the energy system to mobility and influences on the overall energy system

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

CAS in Future Transport Systems: Technology Potential - Key for Type

O Compulsory
W+ Eligible for credits and recommended
W Eligible for credits
E- Recommended, not eligible for credits
Z Courses outside the curriculum
Dr Suitable for doctorate

Key for Hours
V lecture
G lecture with exercise
U exercise
S seminar
K colloquium
P practical/laboratory course
A independent project
D diploma thesis
R revision course / private study

ECTS European Credit Transfer and Accumulation System
■ Special students and auditors need special permission from the lecturers.
Precision Medicine is a new approach in health care aiming to deliver personalized prevention and treatment for human diseases, by taking into account individual differences in lifestyle, environment, and biology.

After taking this course, participants will be able to:
- to describe the goal of precision medicine;
- to explain different next-generation sequencing technologies;
- to illustrate how to make good use of public biological/clinical repositories;
- to demonstrate basic concepts of big data and machine learning;
- to explain how to genotype biological samples for a genetic disease;
- to describe examples of complicated ethical or clinical situations in personalized medicine.
### CAS in Modern Concepts in Clinical Research - Key for Type

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### Key for Hours

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<td>practical/laboratory course</td>
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<td>independent project</td>
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<td>D</td>
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<td>R</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
CAS in Natural Hazard - Risk Management

Offered only in the Spring Semester.

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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Cas in Nutrition for Disease Prevention and Health

#### Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<td>752-6101-00L</td>
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<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. B. Zimmermann</td>
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<td>Abstract</td>
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<td>To have the student gain understanding of</td>
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<td>effect of foods and food ingredients in</td>
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<td>sports nutrition science into practical</td>
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<td>sports nutrition examples.</td>
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<td>be some mandatory as well as voluntary</td>
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<td>General knowledge about nutrition,</td>
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<td>course builds on basic nutrition and</td>
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<td>The course is designed for 3rd year</td>
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<td>Bachelor students, Master students and</td>
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<td>F. von Meyenn, E. Gasser</td>
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<td>Gives the students background knowledge</td>
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<td>the functioning, as well as the</td>
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<td>malfunctioning, of major organ systems on</td>
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<td>Some basic knowledge in physiology is</td>
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<td>important physiological topics,</td>
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<td>cardiovascular physiology and water</td>
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#### CAS in Nutrition for Disease Prevention and Health - Key for Type

| O | Compulsory       | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

#### Key for Hours

| V | lecture          | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise         | D | diploma thesis |
| S | seminar          | R | revision course / private study |
| K | colloquium       |   |                           |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### CAS in Nutrition in Medicine

#### Modules

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<td>F. von Meyenn</td>
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<tr>
<td>395-0301-00L</td>
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#### CAS in Nutrition in Medicine - Key for Type

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<td>Compulsory</td>
<td>E-</td>
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<td>Z</td>
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<td>W</td>
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#### Key for Hours

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<td>lecture</td>
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<td>practical/laboratory course</td>
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<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
CAS in Pharmaceuticals - From Research to Market

Module 2: Pharma Project Management and Health Communication
Module Title: Only for CAS in Pharmaceuticals.

Objective
Project Management Basics:
- About projects, project management and the project environment
- How to define and plan my project, how to deal with stakeholders and how to manage project risks
- Managing my project team, developing the project plan and launching the project
- Managing my project team, developing the project plan and launching the project
- Monitoring and reporting, project close-out and project leadership
- Project evaluation and portfolio management
- Budget and resource management
Workshop:
- Development of a generic drug product in cross-functional project teams
Communication:
- Intercultural communication
- Negotiation skills
- Presentation power

Module 7: Clinical Development
Module Title: Does not take place this semester. Only for CAS in Pharmaceuticals.

Objective
- Preclinical bridge to clinical development
- Strategy for clinical development
- Regulatory aspects of clinical development
- Good clinical practice (GCP) and quality assurance
- First in human studies (Phase I), Proof of concept studies (Phase II), Registration studies (Phase III), Post-registration studies (Phase IV)
- Monitoring
- Organizational and financial aspects of clinical development
- Portfolio and life cycle management
- Data management and simulation of a clinical study
- Personalized medicine

Essay
Module Title: Only for CAS in Pharmaceuticals.

Objective
The essay documents the student’s competence development during the program as well as the transfer of acquired knowledge to professional practice/activities.

Literature
www.postgraduate.pharma.ethz.ch
documents: essay

CAS in Pharmaceuticals - From Research to Market - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>ETS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>O</td>
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<td>E-</td>
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<td>Eligible for credits and recommended</td>
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<td>Courses outside the curriculum</td>
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Key for Hours

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<th>Key</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Core Courses and Seminars

### 079-0100-00L Seminar Basics

Only for CAS in Preservation and MAS in Preservation and Construction History

**Abstract**
The seminar provides an introduction to the basics of scientific work. It imparts methods of architectural and cultural studies, introduces participants to archive-based research and enables them to critically and analytically evaluate the sources consulted. Forms of communicating scientific results are also a topic of the seminar.

**Objective**
The aim of the seminar is to qualify participants to apply methods of architectural and cultural studies in the evaluation of objects of the built environment. Participants are enabled to assess a building which they have selected in the form of a heritage conservation report. This lays the foundation for the second part, which deals with the independent scientific evaluation of a building which the participants choose individually.

**Content**
An essential basis for a responsible engagement with the built heritage is the ability to recognise its characteristics and peculiarities from an architectural scientific point of view, and to objectively elaborate on them. For this, knowledge of scientific methods is just as much a prerequisite as the ability to undertake purposeful research and to critically evaluate source material in order to productively include it in the analysis. The first part of the seminar is devoted to an introduction to scientific work in the fields of architectural and cultural studies. This lays the foundation for the second part, which deals with the independent scientific evaluation of a building which the participants choose individually.

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<thead>
<tr>
<th>Number</th>
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<td>079-0100-00L</td>
<td>Seminar Basics</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>S. Langenberg</td>
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### 079-0101-00L Seminar Texts on Preservation

Only for CAS in Preservation and MAS in Preservation and Construction History

**Abstract**
In the seminar, selected texts on architectural theory and monument preservation are read together and discussed in plenary. The focus is on selected writings from John Ruskin, Gottfried Semper and Friedrich Nietzsche to Alois Riegl and Adolf Loos to Walter Benjamin, Aleida Assmann and Peter Zumthor.

**Objective**
Skills in reading complex theoretical and literary writings on architecture and monument preservation are taught. With increasing practice, these enable participants to undertake an independent appropriation of architectural theory and monument preservation content.

**Content**
The writings on architectural theory and historic preservation discussed in the seminar provide an overview of the most important theories and concepts of historic preservation. Ruskin’s narrative of architectural historicity, Semper’s conception of “Bekleidung” and Nietzsche’s transformation of mythology are covered, as are Riegl’s notions of “Erinnerungswert” and “Gegenwartswert”. Loos’ writings on architecture, Benjamin’s notion of aura and Aleida Assmann’s memory space as well as Peter Zumthor’s atmosphere. Each text is discussed in terms of textual structure, conceptual history, visual language, relationship to poetry and literature, strategies of theory, etc. Identifying the levels and intersections that link a theory with other theories characterises one of the main tasks of our seminar.

**Literature**
- Georg Dehio, Kunsthistorische Aufsätze, Munich 1914.
- Uta Hassler/Winfried Nerdinger, Das Prinzip der Rekonstruktion, Zurich 2010.

### 063-0911-22L Future Monuments

**Abstract**
Heritage conservation is dedicated to the preservation and protection of historical buildings. In this lecture, students will learn about the theoretical positions on historic monuments and the basics of preservation in practice.

**Objective**
In addition to active participation in the discussions, students will be asked to engage with a topic or object of their own choice in order to be able to develop and comprehensively justify their own positions within the context of preservation. Our goal here is to foster students’ communication skills and the culture of discussion.

**Content**
The responsible reconstruction and further development of the existing building stock requires knowledge and an understanding of the theoretical positions conservation and the basics of preservation in practice. This core conveys this knowledge to students with the help of selected writings and discusses them in the context of various guest lectures. In addition to dealing with historical buildings, the course is also dedicated to younger (and very young) objects and inventories - for in addition to the preservation of already listed objects, the selection and inventorisation of future protected objects is also one of the core tasks of heritage conservation.

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<th>Number</th>
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</tbody>
</table>
Literature

READING LIST

Monographs and edited volumes:


Dehio, Georg, Kunsthistorische Aufsätze. München 1914


Huse, Norbert (Hg.), Denkmalpflege: Deutsche Texte aus drei Jahrhunderten, München 1984.

ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


Petzet, Michael und Gert Mader (Hg.), Praktische Denkmalpflege, Stuttgart/ Berlin/ Köln 1993.


Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


Wohlleben, Marion und Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren - nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:

Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008

Stadt Zürich Hochbaudepartement, Amt für Städtebau (Hg.), Bauten, Gärten und Anlagen 1960 bis 1980. Inventarergänzung, August 2013


Denkmalpflegegesetzgebung in den Heimatkantonen der Kursteilnehmenden.

Die Kunstdenkmäler der Schweiz

INSA – Inventare der Heimatkantone der Teilnehmenden
The course elaborates the legal concept of "monument" in its important distinction from the respective scientific concept. It highlights its embeddedness and effect in public building law. Furthermore, it deals with legal protection instruments and procedures. The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a "monument", structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with the procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer's (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.

### Major Courses and Cooperations

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<tr>
<th>Number</th>
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<tr>
<td></td>
<td>Abstract: The course elaborates the legal concept of “monument” in its important distinction from the respective scientific concept. It highlights its embeddedness and effect in public building law. Furthermore, it deals with legal protection instruments and procedures.</td>
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<td>Objective: In addition to elaborating the legal concept of monuments, the course familiarises participants with legal protection instruments and procedures. It is planned to involve the participants by means of practical examples.</td>
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<td>Content: The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a &quot;monument&quot;, structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with the procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer's (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.</td>
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<tr>
<td>079-0151-00L</td>
<td>Theory and History of Preservation in the German-speaking Realm</td>
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<td></td>
<td>Abstract: The course provides an overview of theory formation in heritage conservation. The focus is on European history and German-language texts.</td>
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<td>Objective: The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation from antiquity to the 21st century, and to contrast the different approaches to thought and their development</td>
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<td>Content: In order to get to know the formation of theory, its paths and detours, the most important terms and persons in the history of monument conservation are introduced. Based on various texts, the history of the protection of architectural monuments since antiquity is illuminated. Further focal points in the history of monument preservation were during the Enlightenment, the French Revolution and in the process of the formation of nation states. The discourse on the concept and practice of monument conservation as we understand it today was led by a number of conservators in the German-speaking world around 1900. War-related destruction and the incipient building boom in Europe led to modern debates on the theory of monuments, which are still relevant today. Dealing with monument values is not an end in itself; it can be essential for the preservation of the monument or for historical mediation. Critical positions on the tasks, goals or practices of heritage preservation can only be developed against the background of a knowledge of its historical approaches.</td>
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<td></td>
<td>Leo Schmidt, Einführung in die Denkmalpflege, Darmstadt 2008.</td>
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<td></td>
<td>Wolfgang Götz, Beiträge zur Vorgeschichte der Denkmalpflege. Die Entwicklung der Denkmalpflege in Deutschland vor 1800 (Diss. Leipzig 1956), Zurich 1999 (Veröffentlichungen des Instituts für Denkmalpflege an der ETH Zürich, vol. 20).</td>
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<td>Gottfried Kiesow, Einführung in die Denkmalpflege, Darmstadt 1982.</td>
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<td></td>
<td>Denkmalschutz. Texte zum Denkmalschutz und zur Denkmalpflege, Bonn 1996 (Schriftenreihe des Deutschen Nationalkomitees für Denkmalschutz, vol. 52).</td>
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### Prerequisites / notice

To follow

### CAS in Preservation - Key for Type

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Data: 01.12.2022 12:41  Autumn Semester 2022  Page 479 of 2416
### Key for Hours

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<tr>
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<td>D</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### CAS Thesis

<table>
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<th>Number</th>
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<td>7 credits</td>
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**Abstract**
In their CAS thesis, participants synthesize their learning and apply their insights to their own institutions or examine a relevant topic employing the course methodologies.

**Objective**
Practical application of course content and concepts.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Analytical Competencies</th>
<th>Problem-solving</th>
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<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>

###CAS in Public Governance and Administration - Key for Type

| Z   | Courses outside the curriculum | W+ | Eligible for credits and recommended |
| Dr  | Suitable for doctorate         | W  | Eligible for credits                |
| O   | Compulsory                     | E- | Recommended, not eligible for credits |

### Key for Hours

| V   | lecture                        | P  | practical/laboratory course       |
| G   | lecture with exercise          | A  | independent project               |
| U   | exercise                       | D  | diploma thesis                    |
| S   | seminar                        | R  | revision course / private study   |
| K   | colloquium                     |    |                                 |

**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## CAS in Radiopharmaceutical Chemistry, Radiopharmacy

### Modules

<table>
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<tr>
<th>Number</th>
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<td>4 credits</td>
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<td>Only for CAS in Radiopharmazteutischer Chemie, Radiopharmacy.</td>
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<td>The enrolment is done by the CAS study administration.</td>
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<td>Module I:</td>
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<td>Knowledge of the fundamentals of development, preparation, testing</td>
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<td></td>
<td>and stability of sterile radiopharmaceutical preparations.</td>
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<td></td>
<td>Acquisition of basic information on European legislation in Radiopharmacy including GMP and Pharmacopoeia.</td>
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<td></td>
<td>Understanding basics of gene engineering and pharmacokinetics</td>
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<td>Good manufacturing practice (GMP) of classical radiopharmaceuticals</td>
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<td>GMP: industrial point of view</td>
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<td>Molecular and cellular aspects of radiobiology</td>
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<td>Pharmacopoeia</td>
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<td>Pharmacopoeia – how to use it</td>
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<td>Design of dosage forms for pharmaceuticals</td>
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<td>Pharmaceutical packaging</td>
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<td>Methods of preparation of sterile products</td>
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<td>Aseptic preparation</td>
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<td>The role of excipients in parenteral radiopharmaceutical preparations</td>
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<td>Sterility testing and endotoxin determination</td>
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<td>Particulate contamination</td>
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<td>Principles of medicinal chemistry</td>
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<td>An overview of modern pharmaceutical analysis</td>
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<td>Genetic engineering</td>
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<td></td>
<td>Stability and shelf-life of pharmaceuticals</td>
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<td>(in)stability of radiopharmaceuticals</td>
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<td>Legislation in radiopharmacy</td>
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<td>European directives – GMP</td>
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<td>Specific radiopharmaceutical legislation</td>
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<td>Clinical trials directive and related documents</td>
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<td>The small scale, non-commercial preparation of radiopharmaceuticals</td>
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<td>GMP of PET radiopharmaceuticals</td>
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<td>Quality assurance and preparation of SOP</td>
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<td>Water for pharmaceutical use</td>
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<td>Practicals: visit to hospital radiopharmacy</td>
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<td>Basic concepts of pharmacokinetics</td>
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<td>Drug regulatory affairs</td>
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<td>Microbiology in Pharmacy</td>
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<td>Visit to pharmaceutical company</td>
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<td>542-0003-00L</td>
<td>Module III: Radiopharmacology and Clinical Radiopharmacy</td>
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<td>6G</td>
<td>R. Schibli, R. Furegati Hafner</td>
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<td>The enrolment is done by the CAS study administration.</td>
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<td>Module III:</td>
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<td></td>
<td>Knowledge about the fundamentals of pharmacokinetics and pharmacokinetic modelling, the basic concepts of pharmacology and toxicology, radiopharmaceutical monographs in the European pharmacopoeia, radiological imaging modalities and the basics of applied statistics in biomedical research. Understanding the fundamentals of nuclear medicine: Diagnostic applications in neurology and oncology therapy.</td>
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<td>Pharmacokinetics and kinetic-modelling</td>
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<td>Statistics and practical session</td>
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<td>Radiotracers in biochemistry and molecular pharmacology</td>
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<td>Selective modification of peptides and proteins to target GPCRs</td>
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<td></td>
<td>Demonstration of experimental set up: Peptide and protein modification, radioactive assays in biochemistry</td>
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<td>Visit ABX Radeberg</td>
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<td>Nuclear medicine: basics and therapy</td>
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<td>Immunology</td>
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<td></td>
<td>Drug interventions/interactions/adverse reactions</td>
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<td>Pharmacology basics, special aspects, clinical studies</td>
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<td>Testsystems in toxicology and targeted therapeutics and nucleic acids</td>
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<td>Nuclear medicine: clinical diagnostic applications in neurology</td>
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<td>Nuclear medicine: visit to SPECT facility and radiopharmaceutical GMP lag (Tc, Ga, therapy)</td>
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<td>Radiological imaging modalities- technology and applications</td>
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<td></td>
<td>Nuclear medicine: clinical diagnostic applications in oncology</td>
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<td>Radiopharmaceutical monographs in the European pharmacopoeia</td>
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<td>Practical session, visit: cyclotron, GMP PET production and quality control, PET and PET/CT, therapy unit</td>
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<td>Radioligand-binding-assays/autoradiography</td>
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<td>In house tours in groups: radioligand-binding-assays, autoradiography, metabolite analytics with LC-MS, cyclotron and radiochemistry, highlights in Leipzig</td>
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<td>Biological effects of radiation</td>
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<td>Radiotracer transport and blood brain barrier</td>
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<td>Radiotracers for neuroimaging</td>
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**CAS in Radiopharmaceutical Chemistry, Radiopharmacy - Key for Type**

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<tr>
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<td>Eligible for credits</td>
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<tr>
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<td>Recommended, not eligible for credits</td>
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<td>Dr</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 482 of 2416
### Key for Hours

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<tr>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**
- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
## Lectures

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>115-0510-00L</td>
<td>Lecture Week 10: Spatial Development</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>M. Nollert, J. Van Wezemael</td>
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<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning</td>
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<tr>
<td>Abstract</td>
<td>In this course, the fundamental methods in spatial planning learned in the first week, in particular regarding planning methodology, spatial design and argumentation are consolidated in lectures and case studies.</td>
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<tr>
<td>Objective</td>
<td>The aim of the lecture is the consolidation and the practice of important methodic principles in spatial planning. They provide a basis also for the work in the second Study Project of the MAS program.</td>
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<tr>
<td>115-0511-00L</td>
<td>Lecture Week 11: Urban Planning and Urban Design II</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>S. Kretz, to be announced</td>
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<td>Only for MAS, DAS and CAS in Spatial Planning</td>
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<tr>
<td>Abstract</td>
<td>The second week on urban design and urban planning focuses on a case study in the field of strategic urban design. The course includes lectures, discussions, methodological inputs and a design workshop. Students analyze and discuss a real life problem and elaborate proposals for a suitable urban design strategy.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The aim of the course is an in-depth understanding of contemporary urban design challenges and an exemplary, case-based experience of elaborating adequate urban design strategies.</td>
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<tr>
<td>115-0512-00L</td>
<td>Lecture Week 12: Spatial Planning: Theory and Methodology</td>
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<td>2</td>
<td>1G</td>
<td>A. Voigt</td>
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<td>Only for MAS, DAS and CAS in Spatial Planning</td>
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<tr>
<td>Abstract</td>
<td>Impart thinking patterns and active application of fundamentals of planning theories and methods. The main focus is on plausibility and rigor of reasoning in spatial planning, from problem definition and analysis of its causes to the formulation of robust solutions; development of different planning steps considering communication theory and ethical aspects.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Autonomous and productive application of analyzed thinking patterns and planning steps; situationally appropriate and task-oriented transfer to new planning problems.</td>
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<tr>
<td>115-0513-00L</td>
<td>Lecture Week 13: Academic Working in Spatial Planning</td>
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<td>2</td>
<td>1G</td>
<td>R. Nebel, A. Rupf</td>
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<td>Only for MAS, DAS and CAS in Spatial Planning</td>
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<tr>
<td>Abstract</td>
<td>Understanding what scientific work means in spatial planning. Procedures for clarification processes; basics of scientific working and writing; case studies and exercises.</td>
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<tr>
<td>Objective</td>
<td>Knowledge for a scientific way of working; structuring a scientific paper using the example of the DAS Synopsis or MAS Thesis.</td>
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<tr>
<td>115-0514-00L</td>
<td>Lecture Week 14: Spatial Planning: International Aspects</td>
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<td>2</td>
<td>1G</td>
<td>F. Persyn</td>
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<td>Only for MAS, DAS and CAS in Spatial Planning</td>
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<tr>
<td>Abstract</td>
<td>Introduction to international perspectives in spatial planning. Exploring various scales and their interconnectedness as well as flows and practices that bridge different cultures of planning. International competitions as a tool to navigate different planning realities, terrains and transformations. Team work on an ongoing case.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Learning from different spatial planning cultures, their interaction and improving the capacity to understand and bring solutions to diverse planning contexts.</td>
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### CAS in Spatial Planning - Key for Type

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<tr>
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<td>W</td>
<td>Eligible for credits</td>
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<tr>
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<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
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<tr>
<td>Dr</td>
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### Key for Hours

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<tbody>
<tr>
<td>V</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>practical/laboratory course</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
## Module

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<td>General Knowledge</td>
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<td>Only for CAS in Regenerative Materials - Hygrothermal Specialisation.</td>
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<tr>
<td>136-0202-00L</td>
<td>Constructive Details &amp; Implementation</td>
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<td>136-0203-00L</td>
<td>Advanced Knowledge</td>
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## Project

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### CAS in Regenerative Materials - Hygrothermal Specialisation - Key for Type

- **O**: Compulsory
- **W+**: Eligible for credits and recommended
- **W**: Eligible for credits
- **E-**: Recommended, not eligible for credits
- **Z**: Courses outside the curriculum
- **Dr**: Suitable for doctorate

### Key for Hours

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium
- **P**: practical/laboratory course
- **A**: independent project
- **D**: diploma thesis
- **R**: revision course / private study

### ECTS

- European Credit Transfer and Accumulation System

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# CAS in Regulatory Thinking

## Modules

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<td>395-0200-00L</td>
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<td>395-0201-00L</td>
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<td><em>Only for CAS in Regulatory Thinking and MAS in digital Clinical Research</em></td>
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<tr>
<td>395-0202-00L</td>
<td>Intended Use / Indication</td>
<td>O</td>
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<td>395-0203-00L</td>
<td>Production / GMP</td>
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<td>P</td>
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<td></td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
<td></td>
</tr>
</tbody>
</table>

**ECTS**

- **European Credit Transfer and Accumulation System**
- **Special students and auditors need special permission from the lecturers.**
CAS in Robotics

Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>172-0100-00L</td>
<td>CAS Module in Robotics and AI</td>
<td>O</td>
<td>12 credits</td>
<td>26A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract

In the CAS Robotics participants are offered a RobotX professor as a mentor together with whom they design their study plan along an individually-specified focus area in the area of Robotics and AI. Based on the individual expertise and interests of the participants, the customised Robotics and AI module consists of a combination of (i) research project, (ii) lectures, (iii) knowledge transfer.

Objective

The CAS Robotics and AI module offers experienced industry individuals the opportunity to undergo research-related training in Robotics and AI, to update their knowledge and to expand their area of expertise in a targeted manner and aims at:
- training skills at the frontiers of the current state of research in Robotics and AI,
- deepening technical know-how with state-of-the-art knowledge in the specified focus area, and
- advancing practical competencies in the impart of expertise and knowledge transfer across disciplines and educational levels.

CAS in Robotics - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### CAS in Seismic Evaluation and Retrofitting

Offered only in the Autumn Semester.

#### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>139-0101-00L</td>
<td>Module 1: Introduction to Seismic Design and Swiss Seismic Code Provisions Only for CAS in Seismic Evaluation and Retrofitting.</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>A. Tsiavos, B. Stojadinovic</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The objective of this Module is to introduce the principles of Seismic Design of Structures and the Swiss Seismic Code Provisions to Civil Engineers working in Switzerland.</td>
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<tr>
<td></td>
<td>Objective</td>
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</tr>
<tr>
<td></td>
<td>- To understand the critical points of the Swiss Code Provisions for the seismic design of new structures and the seismic evaluation of existing structures</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- To get an overview in the dynamics and the principles of seismic design of structures</td>
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<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>1.1 Introduction to seismic hazard and seismic risk, seismic performance objectives, common structural deficiencies and observed damage patterns due to earthquake ground motion excitation</td>
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<tr>
<td></td>
<td>1.2 Seismic elastic and inelastic response of SDOF systems and earthquake response spectra</td>
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<tr>
<td></td>
<td>1.3 Seismic elastic and inelastic response of MDOF systems, Response Spectrum Analysis and Pushover Analysis</td>
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<tr>
<td></td>
<td>1.4 Seismic Design of structures using SIA 261: Presentation and Examples</td>
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<tr>
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<td>1.5 Good practices for the seismic design of new structures</td>
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<td></td>
<td>1.6 Seismic safety of non-structural components</td>
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<tr>
<td></td>
<td>1.7 Swiss Code Provisions for the seismic evaluation of existing structures SIA 269/8: Presentation and examples, Evaluation of commensurability of seismic retrofitting measures</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
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</tr>
<tr>
<td></td>
<td>- Anwesenheit (mind. 80% pro Präsenzwoche) und aktive Mitarbeit in den Präsenzwochen</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- mindestens genügende Leistungen bei Leistungskontrollen</td>
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</tr>
<tr>
<td>139-0102-00L</td>
<td>Module 2: Finite Element Modelling and Identification of the Seismic Behavior of Structures Only for CAS in Seismic Evaluation and Retrofitting.</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>A. Tsiavos, B. Stojadinovic</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>This module enables participants:</td>
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</tr>
<tr>
<td></td>
<td>- To use the state-of-the-art FEM software and implement the optimal FE modelling techniques for the simulation of the seismic response of existing buildings (concrete, masonry, mixed concrete-masonry) located in Switzerland</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- To obtain knowledge of the FEM software and the modelling techniques for the simulation of soil-structure interaction</td>
<td></td>
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<tr>
<td></td>
<td>- To understand the current methodologies for the identification and monitoring of the vibration and the seismic behavior of structures located in Switzerland.</td>
<td></td>
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</tr>
<tr>
<td>139-0103-00L</td>
<td>Module 3: Analysis Methods and Case Study Examples of Seismic Evaluation and Retrofitting Only for CAS in Seismic Evaluation and Retrofitting.</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>A. Tsiavos, B. Stojadinovic</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>The scope of this Module is to present Analysis Methods and Case Study Examples that illustrate established procedures and practical engineering solutions that are applied in the seismic evaluation and retrofitting of existing structures by Civil Engineers working in Switzerland.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>This module enables participants:</td>
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<tr>
<td></td>
<td>- To acquire practical knowledge of the seismic retrofitting techniques commonly used in Switzerland, their implementation and their cost</td>
<td></td>
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<tr>
<td></td>
<td>- To select the appropriate analysis method for the seismic evaluation of structures located in Switzerland and understanding of the governing factors</td>
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</tr>
<tr>
<td>139-0104-00L</td>
<td>Module 4: Individual Project Exercise Only for CAS in Seismic Evaluation and Retrofitting.</td>
<td>O</td>
<td>4</td>
<td>2P</td>
<td>A. Tsiavos, B. Stojadinovic</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
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<tr>
<td></td>
<td>This modules enables participants</td>
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<tr>
<td></td>
<td>- To conduct independently a seismic evaluation of an existing structure located in Switzerland considering the boundary conditions that influence the seismic behavior of the structure</td>
<td></td>
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</tr>
</tbody>
</table>

#### CAS in Seismic Evaluation and Retrofitting - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

#### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
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<td>U</td>
<td>exercise</td>
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<td>diploma thesis</td>
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</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Markets play an important function in modern societies by allocating resources and capital. Yet, important market failures require the intervention of public policy. This module introduces the fundamentals of micro- and macro-economics and thereby lays the foundation for the economic assessment of policy interventions.

How Markets Function (Microeconomics):
Participants understand (1) the role risk and uncertainty play in decision-making; (2) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (3) how to assess policy alternatives, using various ex ante policy analysis methods; (4) how to communicate the results of the analysis. Participants understand (1) particular prerequisites for successful dissemination of scientific results to policy-makers and the wider public, (2) expectations and needs of different target groups and audiences, (3) how to effectively write policy briefs for stakeholders and policy-makers.

Introduction:
Participants understand (1) what ex ante and ex post policy impact analysis is, (2) in what forms and with what methods they can be undertaken, (3) why they are important for evidence-based policy-making.

Analysis of Policy and Technology Options:
Participants understand (1) how to perform policy analyses related to technology; (2) a policy problem and the rationale for policy intervention; (3) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (4) how to assess policy alternatives, using various ex ante policy analysis methods; (5) and how to communicate the results of the analysis. Participants understand (1) how to perform policy analyses related to technology; (2) a policy problem and the rationale for policy intervention; (3) why they are important for evidence-based policy-making.

Evaluation of Policy Outcomes:
Participants understand (1) when and why policy outcomes can be evaluated based on observational or experimental methods, (2) basic methods for evaluating policy outcomes (e.g. causal inference methods and field experiments), (3) how to apply concepts and methods of policy outcome evaluation to specific cases of interest.

Participants understand (1) when and why policy outcomes can be evaluated based on observational or experimental methods, (2) basic methods for evaluating policy outcomes (e.g. causal inference methods and field experiments), (3) how to apply concepts and methods of policy outcome evaluation to specific cases of interest.

Big Data Approaches to Policy Analysis:
Participants understand (1) why “big data” techniques for making policy-relevant assessments and predictions are useful, and under what conditions, (2) key techniques in this area, such as procuring big datasets; processing and dimension reduction of massive datasets for tractable computation; machine learning for predicting outcomes; interpreting machine learning model predictions to understand what is going on inside the black box; data visualization including interactive web apps.

Participants understand (1) the role risk and uncertainty play in decision-making; (2) how to apply methods of quantitative risk analysis, (4) how to communicate risk information clearly and effectively.

Writing for Policy-Makers:
Participants understand (1) particular prerequisites for successful dissemination of scientific results to policy-makers and the wider public, (2) expectations and needs of different target groups and audiences, (3) how to effectively write policy briefs for stakeholders and policy-makers.

Participants understand (1) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (3) how to apply methods of quantitative risk analysis, (4) how to communicate risk information clearly and effectively.

International Economic Relations
Participants understand (1) the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates, (2) why national economic activity fluctuates, (3) what economic policy can do against unemployment and inflation, (4) what significance international economic relations have for specific countries, such as Switzerland.

How Economic Systems Function (Macroeconomics):
Participants understand (1) the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates, (2) why national economic activity fluctuates, (3) what economic policy can do against unemployment and inflation, (4) what significance international economic relations have for specific countries, such as Switzerland.

Introduction:
Participants understand (1) what ex ante and ex post policy impact analysis is, (2) in what forms and with what methods they can be undertaken, (3) why they are important for evidence-based policy-making.

Analysis of Policy and Technology Options:
Participants understand (1) how to perform policy analyses related to technology; (2) a policy problem and the rationale for policy intervention; (3) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (4) how to assess policy alternatives, using various ex ante policy analysis methods; (5) and how to communicate the results of the analysis.

Evaluation of Policy Outcomes:
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Participants understand (1) the role risk and uncertainty play in decision-making; (2) how to apply methods of quantitative risk analysis, (4) how to communicate risk information clearly and effectively.

Writing for Policy-Makers:
Participants understand (1) particular prerequisites for successful dissemination of scientific results to policy-makers and the wider public, (2) expectations and needs of different target groups and audiences, (3) how to effectively write policy briefs for stakeholders and policy-makers.
### CAS in Transport Engineering

#### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>149-0001-00L</td>
<td>Transport Planning - Theory and Models</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>K. W. Axhausen</td>
</tr>
<tr>
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<td>Does not take place this semester. Only for CAS in</td>
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<tr>
<td></td>
<td>Transport Engineering and MAS in Future Transport</td>
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<td>Systems</td>
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<tr>
<td>149-0002-00L</td>
<td>Traffic Engineering</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
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<td>Does not take place this semester. Only for CAS in</td>
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<tr>
<td></td>
<td>Transport Engineering and MAS in Future Transport</td>
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<td></td>
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<tr>
<td></td>
<td>Systems</td>
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</tbody>
</table>

### CAS in Transport Engineering - Key for Type

| O   | Compulsory                                         |
| W+  | Eligible for credits and recommended               |
| W   | Eligible for credits                                |
| E-  | Recommended, not eligible for credits               |
| Z   | Courses outside the curriculum                      |
| Dr  | Suitable for doctorate                              |

### Key for Hours

| V   | lecture                                           |
| G   | lecture with exercise                              |
| U   | exercise                                          |
| S   | seminar                                           |
| K   | colloquium                                        |
| P   | practical/laboratory course                       |
| A   | independent project                               |
| D   | diploma thesis                                    |
| R   | revision course / private study                    |

### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
### Chemistry (General Courses)

#### General Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0073-00L</td>
<td>Radiochemistry</td>
<td>Z</td>
<td>2 credits</td>
<td>2V</td>
<td>to be announced</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
<td></td>
<td>Principles and phenomena around radioactivity.</td>
</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
<td></td>
<td></td>
<td>Knowledge of the most important phenomena in relation with radioactivity. Knowledge of the principles of radiation protection. Ability to judge dangerous situations in handling radioactive materials, geopolitically as well as locally at one's own working place.</td>
</tr>
<tr>
<td></td>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
<td>Structure and properties of atomic nuclei, mathematical description of the radioactive decay, decay types, interaction of radiation with matter, detectors for ionizing radiation, radiation protection, principles of isotope separation, nuclear power plants, major nuclear accidents. Additional topics may be suggested by the students.</td>
</tr>
<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td></td>
<td>A script is available free of charge.</td>
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<tr>
<td></td>
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<td></td>
<td>Weitere Literaturangaben werden nach Bedarf in der Vorlesung abgegeben.</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
<td></td>
<td>Institute-Seminar covering current research Topics in Physical Chemistry</td>
</tr>
<tr>
<td>529-0688-00L</td>
<td>Safety Lecture for Assistants</td>
<td>Z</td>
<td>0 credits</td>
<td>1K</td>
<td>T. Mäder</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
<td></td>
<td>Safety-Praxis und Riskmanagement in Laboratorien</td>
</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
<td></td>
<td></td>
<td>Gute Safety-Praxis</td>
</tr>
<tr>
<td></td>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
<td>Safety-Regeln, Riskmanagement im Labor, Safety-Parcours</td>
</tr>
</tbody>
</table>

### Chemistry (General Courses) - Key for Type

| O  | Compulsory        | E-  | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z   | Courses outside the curriculum |
| W  | Eligible for credits | Dr  | Suitable for doctorate |

### Key for Hours

| V  | lecture         | P   | practical/laboratory course |
| G  | lecture with exercise | A   | independent project |
| U  | exercise        | D   | diploma thesis |
| S  | seminar         | R   | revision course / private study |
| K  | colloquium      |     |                             |

### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
Chemistry Bachelor

1. Semester

Compulsory Subjects First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-02L</td>
<td>General Chemistry (inorganic Chemistry) I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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</tbody>
</table>

| 529-0011-03L | General Chemistry (Organic Chemistry) I | O    | 3 credits | 2V+1U | P. Chen |
|          | **Objective**                              |      |      |       |                    |
|          | Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicality, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intermolecular interactions. |
|          | **Content**                                |      |      |       |                    |
|          | **Lecture notes**                          |      |      |       |                    |
|          | Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt |
|          | **Literature**                             |      |      |       |                    |

| 529-0011-01L | General Chemistry (Physical Chemistry) I | O    | 3 credits | 2V+1U | H. J. Wörner |
|          | **Abstract**                               |      |      |       |                    |
|          | The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding. |
|          | **Objective**                              |      |      |       |                    |
|          | After the lecture, students will be able to, |
|          | - to calculate physical quantities and their units which are important for chemistry, |
|          | - name some properties of chemically relevant particles and propose experimental methods to determine these properties, |
|          | - name applications and hazards of radioactivity, |
|          | - categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them, |
|          | - describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection, |
|          | - to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them, |
|          | - analyze and calculate absorption and emission spectra of single-electron atoms, |
|          | - to set up the Schrödinger equation for a molecular multi-particle system, |
|          | - independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems, |
|          | - model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model, |
|          | - explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom, |
|          | - explain the structure of the periodic table of elements with the help of the orbital concept, |
|          | - recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and |
|          | - establish term symbols for atomic ground states. |
|          | **Content**                                |      |      |       |                    |
|          | Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions, Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger’s equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals. |
|          | **Lecture notes**                          |      |      |       |                    |
|          | See homepage of the lecture. |
|          | **Literature**                             |      |      |       |                    |
|          | See homepage of the lecture. |
|          | **Prerequisites / notice**                 |      |      |       |                    |
|          | Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung. |
Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.

Objective
The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

Content
Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids)
Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

Lecture notes
The lecture follows the book “Physics” by Paul A. Tipler.

Literature
Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company

Mathematical Foundations I: Analysis A

Abstract
Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

Objective
Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

Content
Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Literature
G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag
R. Sperb/M. Akveld: Analysis I (vdf)
L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

Further reading suggestions will be indicated during the lecture.
Objective

Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation state and redox behaviour (syntheses), redox-titrations, galvanic elements, metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration) analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimeter, solubility).

Content

The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get a view of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their states of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes

http://www.gruetzmacher.ethz.ch/education/labcourses

Literature


Prerequisites / notice

Compulsory: online enrolment latest one week before start of the semester

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

3. Semester

Compulsory Subjects Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0121-00L</td>
<td>Inorganic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. Grützmacher, P. Steinegger</td>
</tr>
<tr>
<td>529-0221-00L</td>
<td>Organic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. Wennemers</td>
</tr>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>R. Signorell</td>
</tr>
</tbody>
</table>

Objective

This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

Content

The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.

Lecture notes

The lecture slides, problem sets, and additional documents are provided online. Link: https://Wennemers.ethz.ch/education/html

Literature

**Objective**
Introduction to Chemical Reaction Kinetics

**Content**

**Lecture notes**
Will be provided

**Literature**

**Prerequisites / notice**
Voraussetzungen:
- Mathematik I und II
- Allgemeine Chemie I und II
- Physikalische Chemie I

---

**529-0051-00L Analytical Chemistry I**

**Objective**
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

**Content**
- Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
  - Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
  - NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
  - IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

**Lecture notes**
Script will be for the production price

**Literature**
- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995;

**Prerequisites / notice**
Excercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

---

**401-0373-00L Mathematics III: Partial Differential Equations**

**Abstract**

**Objective**
Classical tools to solve the most common linear partial differential equations.

**Content**
1) Examples of partial differential equations
   - Classification of PDEs
   - Superposition principle
2) One-dimensional wave equation
   - D'Alembert's formula
   - Duhamel's principle
3) Fourier series
   - Representation of piecewise continuous functions via Fourier series
   - Examples and applications
4) Separation of variables
   - Solution of wave and heat equation
   - Homogeneous and inhomogeneous boundary conditions
   - Dirichlet and Neumann boundary conditions
5) Laplace equation
   - Solution of Laplace's equation on the rectangle, disk and annulus
   - Poisson formula
   - Mean value theorem and maximum principle
6) Fourier transform
   - Derivation and definition
   - Interpretation and properties of the Fourier transform
   - Solution of the heat equation
7) Laplace transform (if time allows)
   - Definition, motivation and properties
   - Inverse Laplace transform of rational functions
   - Application to ordinary differential equations

**Lecture notes**
See the course web site (linked under Lernmaterialien)
Literature


Additional books:


4) E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1, 2, 11, 12, 6)

For additional sources, see the course web site (linked under Lernmaterialien)

Required background:

1) Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant

2) Multiple integrals: Riemann integrals in two or three variables, change of variables

3) Sequences and series of numbers and of functions

Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0129-00L</td>
<td>Inorganic and Organic Chemistry II</td>
<td>O</td>
<td>11 credits</td>
<td>16P</td>
<td>V. Mougel</td>
</tr>
</tbody>
</table>

Abstract

Introduction to the experimental methods of Inorganic Chemistry

Objective

The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a main topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques.

Content

Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Lecture notes

A manual is distributed in the teaching laboratory.

Prerequisites / notice

- Passed Basisprüfung
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)
- Continuous Attendance of Course Inorg. Chemistry 1 (3. Sem., 529-0121) and Analytical Chemistry 1 (3. Sem., 529-0051)

If necessary, access priority will be settled according to the results of the first-year examinations.

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

5. Semester

Compulsory Subjects Examination Block II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0132-00L</td>
<td>Inorganic Chemistry III: Organometallic Chemistry and Homogeneous Catalysis</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Bezdek, C. Copéret</td>
</tr>
</tbody>
</table>

Abstract

Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbylation, C-C bond-forming and related reactions.
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carboxylation, C-C bond-forming and related reactions.

Methods of Asymmetric Synthesis

Understanding of the basic principles of diastereoselective synthesis

Conformational analysis: acyclic and cyclic systems; Diastereoselective sigmatropic rearrangements; Diastereoselective Carbyl addition reactions; Cram- and Felkin-Anh models, carbyl Lewis acid interactions, chelate controlled reactions; chemistry of enolates, selective formation; asymmetric enolate alkylation; aldol reactions, allyl- and crotyl-metal chemistry; cyclisations, Baldwin rules; Diastereoselective olefin functionalization: hydroboration, dihydroxylation, epoxidation.

Evans’ Problems in Organic Chemistry App

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Theoretical foundations of magnetic resonance (NMR,EPR) and selected applications.

The course gives an introduction to magnetic resonance spectroscopy (NMR and EPR) in liquid, liquid crystalline and solid phase. It starts from a classical description in the framework of the Bloch equations. The implications of chemical exchange are studied and two-dimensional exchange spectroscopy is introduced. An introduction to Fourier spectroscopy in one and two dimensions is given and simple ‘pulse trickery’ is described. A quantum-mechanical description of magnetic resonance experiments is introduced and the spin Hamiltonian is derived. The chemical shift term as well as the scalar, dipolar and quadrupolar terms are discussed. The product-operator formalism is introduced and various experiments are described, e.g. polarization transfer. Applications in chemistry, biology, physics and medicine, e.g. determination of 3D molecular structure of dissolved molecules, determination of the structure of paramagnetic compounds and imaging (MRI) are presented.

Laboratory experiments to acquire a profound knowledge of spectroscopical methods and techniques in chemistry. Evaluation and visualization of measurement data. Writing lab reports.

Detailed documentaries to each experiment will be handed out.

Laboratory experiments: UV/VIS spectroscopy, luminescence spectroscopy, FT infrared spectroscopy, light diffraction and refraction, thermal lenses, Raman spectroscopy, reflection spectroscopy, optical polarization phenomena, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), FT nuclear magnetic resonance spectroscopy (NMR), electron paramagnetic resonance spectroscopy (EPR), atomic force microscopy (AFM), Fourier transform methods.

Practicals in Spectroscopy and Analytical Chemistry (529-0054-00) or Spectroscopy and Analytical Chemistry (529-0054-01).

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Students are free to choose from a range of D-CHAB chemistry courses appropriate to their level of study (please note admission requirements). In case of doubt, contact the student administration.

Introduction into the important methods for structural analysis (solid state NMR), crystal structure analysis and surface analysis techniques and their applications.
Physical Chemistry

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0441-00L</td>
<td>Signal Processing</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>F. Merkt, U. Hollenstein</td>
</tr>
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</table>


Objective: Basics of signal processing in spectroscopy


Analytical Chemistry

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0041-00L</td>
<td>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>R. Zenobi, B. Hattendorf, P. Sinués Martinez-Lozano</td>
</tr>
</tbody>
</table>

Abstract: Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

Objective: Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

Content: Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, Orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

Biological Chemistry

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0240-00L</td>
<td>Chemical Biology - Peptides</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>H. Wennemers</td>
</tr>
</tbody>
</table>

Abstract: An advanced course on the synthesis, properties and function of peptides in chemistry and biology.

Objective: Knowledge of the synthesis, properties and function of peptides in chemistry and biology.

Content: Advanced peptide synthesis, conformational properties, combinatorial chemistry, therapeutic peptides, peptide based materials, peptides in nanotechnology, peptides in asymmetric catalysis.

Lecture notes: Citations from the original literature relevant to the individual lectures will be assigned weekly.

### Chemical Aspects of Energy

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0659-00L</td>
<td>Electrochemistry: Fundamentals, Cells &amp; Applications</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>L. Gubler</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.

**Objective**
The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of sciences material and engineering and how they are put to use in selected applications.

**Content**
- Introduction: important quantities & units, terminology;
- Chapter I - Redox reactions, Faraday's laws;
- Chapter II - Equilibrium electrochemistry: cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces: electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes: conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry: overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry: electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion: important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors: potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion: corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection.

**Lecture notes**
lecture notes, exercise & solutions (PDF files) via download website

**Literature**

**Prerequisites / notice**
Students should be familiar with the fundamentals of physical chemistry.

### Chemical Crystallography

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0039-00L</td>
<td>Principles of Crystal Structure Determination</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>M. D. Wörle, N. Trapp</td>
</tr>
</tbody>
</table>

**Abstract**
An introduction to the principles of X-ray diffraction and crystal structure determination as it relates to Chemistry.

**Objective**
To gain an understanding of the principles of crystal structure determination by X-ray diffraction.

**Content**
Basic crystallographic concepts: Unit cells, Bravais lattices, Laue symmetry, crystal classes (point groups), space groups, crystal growth, instrumentation, diffraction of X-rays by crystals: physical and geometric basics, powder and single crystal methods, structure solution and modelling, interpretation of crystal structure data; internal coordinates for structure description: atom spacing, co-ordination polyhedra, bond angles, torsion angles; intermolecular interactions, absolute configuration determination. Overview of inorganic, organic and macromolecular databases.

**Lecture notes**
The script and exercises will be distributed weekly in loose form.
Literature

Main reference

Additional literature
(2) J.D. Dunitz, "X-ray Analysis and the Structure of Organic Molecules", 1995, Verlag HCA.

Computational Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0002-00L</td>
<td>Algorithms and Programming for Chemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>S. Riniker, G. Landrum</td>
</tr>
</tbody>
</table>

Abstract
Introduction to algorithms (special focus on chemistry):
Design of algorithms, data structures, search and sort algorithms, graphs, numerical algorithms, algorithms in cheminformatics, machine learning and bioinformatics

Objective
Development of programming skills and craftsmanship in order to be able to deal with the complexity of computer applications in chemistry.

Content
Introduction to algorithms (special focus on chemistry):
Design of algorithms, data structures, search and sort algorithms, graphs, numerical algorithms, algorithms in cheminformatics, machine learning and cheminformatics

Lecture notes
Script (in English) will be available

Literature

Materials Science

Offered during Spring Semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-0312-00L</td>
<td>Materials Synthesis I - Polymers</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>A. Anastasaki, D. Opris</td>
</tr>
</tbody>
</table>

Abstract
The course teaches the basics and terminology of polymer synthesis. To synthesize various polymeric materials, different polymerization techniques are required. This course will introduce representative polymerization methodologies and will discuss how they operate in order to yield materials with enhanced polymeric characteristics.

Objective
1) The students will be able to recognize different polymer types and associate them with their chemical structure and properties (i.e. rubber elasticity, glass transition temperature, etc.)
2) The students will become familiar with various synthetic methods to produce polymers of different architectures and topologies
3) The students will be exposed to different characterization methods (e.g. size exclusion chromatography, mass-spectrometry, nuclear magnetic resonance) that are necessary to confirm the successful synthesis and structure of a polymer
4) The students will understand the mechanism of selected polymerization methodologies
5) The students will be introduced to state-of-the-art polymer synthesis and recent literature examples will be critically discussed

Content
conventional chain growth polymerization, living chain growth polymerization, step growth polymerization, polymeric architectures, molecular weight determination methods, polymer properties, polymerization mechanisms, polymer characterization methods

Lecture notes
Lecture slides with references to further literature will be available on Moodle

Literature
L. Mandelkern "An Introduction to Macromolecules"
J. M. G. Cowie "Polymers: Chemistry and Physics of Modern Materials"
publications mentioned on the slides

Environmental Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0037-01L</td>
<td>Introduction to Environmental Chemistry and</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Hollender, T. Hofstetter, C. S. McDardell</td>
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</tbody>
</table>

Abstract
Anthropogenic activities related to production, use and disposal of goods cause emission of chemicals to the environment. This lecture provides an introduction to the knowledge required for assessing the risk of chemicals to human and environmental health by covering partitioning, reactivity, and toxic effects of chemicals as well as selected aspects of contemporary chemical analyses.

Objective
Students will develop a basic understanding for fate and effects of chemicals in the environment and learn how to use simple quantitative tools for the assessment of chemical behaviour and toxic effects.
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship. The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case. The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

In particular, the aims of the course are to:
(1) broaden understanding of management principles and frameworks
(2) advance insights into the sources of corporate and entrepreneurial success
(3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

The course content focuses on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.

Furthermore, they will practise to explain fundamental concepts in stratospheric chemistry by means of scientific paper presentations.

The students will understand the most important aspects of stratospheric dynamics and the greenhouse gas effect in troposphere and stratosphere.

The students will also acquire a good understanding of the coupling between stratospheric ozone and climate change.

Content
Introduction to the chemical family concept: active species, their source gases and reservoir gases. Detailed treatment of the pure oxygen family (odd oxygen) according to the Chapman chemistry. Radical reactions of the oxygen species with nitric oxide, active halogens (chlorine and bromine) and odd hydrogen. Ozone depletion cycles. Methane depletion and ozone production in the lower stratosphere (photo-smog reactions). Heterogeneous chemistry on the background aerosol and its significance for heavy air traffic. Chemistry and dynamics of the ozone hole: Formation of polar stratospheric clouds and chlorine activation.

Lecture notes
Documents are provided in the contact hours.

Literature

Prerequisites
Basics in physical chemistry are required and an overview equivalent to the bachelor course in atmospheric chemistry (lecture 701-0471-01) is expected.

Economics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
</tr>
</tbody>
</table>

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

In particular, the aims of the course are to:
(1) broaden understanding of management principles and frameworks
(2) advance insights into the sources of corporate and entrepreneurial success
(3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.
<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td></td>
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<td>Critical Thinking</td>
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</table>

▶ Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

▶ Language Courses

see Science in Perspective: Language Courses ETH/UZH

### Chemistry Bachelor - Key for Type

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<thead>
<tr>
<th>O</th>
<th>W+</th>
<th>W</th>
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<tr>
<td>Compulsory</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Z</td>
<td>Dr</td>
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<tr>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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</table>

### Key for Hours

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<tbody>
<tr>
<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<td>P</td>
<td>A</td>
<td>D</td>
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<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma".

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
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<td>Enrolment only possible with matriculation in Teaching</td>
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<td>Diploma or Teaching Certificate (excluding Teaching</td>
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<td>Diploma Sport).</td>
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<td>This course unit can only be enrolled after successful</td>
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<td>participation in, or during enrollment in the course &quot;</td>
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<td>Human Learning (EW 1)&quot;.</td>
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<td>Abstract</td>
<td>This seminar focuses on teaching units in chemistry,</td>
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<td>physics and mathematics that have been developed at the</td>
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<td>MINT Learning Center of the ETH Zurich. In the first</td>
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<td>meeting, the mission of the MINT Learning Center will</td>
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<td>be communicated. Furthermore, in groups of two, the</td>
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<td>students will intensively work on, refine and optimize</td>
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<td>a teaching unit following a goal set in advance.</td>
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<td>Objective</td>
<td>Get to know cognitively activating instructions in MINT</td>
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<td>subjects</td>
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<td>Get information about recent literature on learning and</td>
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<td></td>
<td>instruction</td>
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<tr>
<td>Prerequisites /</td>
<td>Für eine reibungslose Semesterplanung wird um frühe</td>
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<tr>
<td>notice</td>
<td>Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin</td>
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<td>851-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
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<td>Diploma Sport).</td>
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<td>Number of participants limited to 30.</td>
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<td>This course unit can only be enrolled after successful</td>
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<td>participation in, or during enrollment in the course &quot;</td>
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<td>Human Learning (EW 1)&quot;.</td>
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<tr>
<td>Abstract</td>
<td>The focus will be on the book &quot;Intelligenz: Grosse</td>
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<td>Unterschiede und ihre Folgen&quot; by Stern and Neubauer.</td>
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<td>Participation at the first meeting is obligatory.</td>
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<td>It is required that all participants read the complete</td>
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<td>book. Furthermore, in two meetings of 90 minutes,</td>
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<td>concept papers developed in small groups (5 - 10</td>
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<td>students) will be discussed.</td>
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<td>Objective</td>
<td>Understanding research methods used in the empirical</td>
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<td>human sciences</td>
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<td>Getting to know intelligence tests</td>
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<td></td>
<td>Understanding findings relevant for education</td>
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<td>851-0242-08L</td>
<td>Research Methods in Educational Science</td>
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<td>1</td>
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<td>C. M. Thurn, T. Braas,</td>
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<td>Diploma Sport).</td>
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<td>Number of participants limited to 30.</td>
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<td>This course unit can only be enrolled after successful</td>
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<td>participation in, or during enrollment in the course &quot;</td>
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<td>Human Learning (EW 1)&quot;.</td>
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<tr>
<td>Abstract</td>
<td>Literature from the learning sciences is critically</td>
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<td></td>
<td>discussed with a focus on research methods.</td>
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<td>At the first meeting, working groups will be assembled</td>
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<td>and meetings with those will be set up.</td>
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<td>In the small groups students will write critical essays</td>
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<td>about the read literature. At the third meeting, we</td>
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<td>will discuss the essays and develop research questions</td>
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<td>in group work.</td>
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<td>Objective</td>
<td>Understand research methods used in the empirical</td>
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<td>educational sciences</td>
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<td></td>
<td>Understand and critically examine information from</td>
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<td>scientific journals and media</td>
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<td>Understand pedagogically relevant findings from the</td>
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<td>851-0242-11L</td>
<td>Gender Issues In Education and STEM</td>
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<td>2</td>
<td>2S</td>
<td>M. Berkowitz Biran, T.</td>
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<td>Diploma Sport).</td>
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<td>Number of participants limited to 30.</td>
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<tr>
<td>Abstract</td>
<td>In this seminar, we introduce some of the major</td>
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<td></td>
<td>gender-related issues in the context of education and</td>
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<td>science learning, such as the under-representation of</td>
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<td>girls and women in science, technology, engineering</td>
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<td>and mathematics (STEM). Common perspectives,</td>
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<td>controversies and empirical evidence will be</td>
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<td>discussed.</td>
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<td>Objective</td>
<td>Familiarize students with gender issues in the</td>
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<td>educational and STEM context and with controversies</td>
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<td>regarding these issues</td>
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<td>Develop a critical view on existing research and</td>
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<td>perspectives.</td>
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<td>Integrate this knowledge with teacher's work.</td>
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<tr>
<td>Content</td>
<td>Why do fewer women than men specialize in STEM (</td>
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<td>(science, technology, engineering and mathematics)?</td>
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<td>Are girls better in language and boys better in math?</td>
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<td>These and other questions about gender differences</td>
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<td>relevant to education and STEM learning have been</td>
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<td>occurring researchers for decades. In this seminar,</td>
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<td>students learn about major gender issues in the</td>
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<td>educational context and the different perspectives</td>
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<td>for understanding them.</td>
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<td>Prerequisites /</td>
<td>The seminar builds on the active participation of</td>
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<td>notice</td>
<td>students in reading, presenting and critically</td>
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<td>discussing selected papers in the field. We focus on</td>
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<td>empirical research and integrate implications for the</td>
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<td></td>
<td>classroom context. In a final small-group assignment,</td>
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<td></td>
<td>students integrate and elaborate on the topics learned</td>
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<td>in the seminar.</td>
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<tr>
<td>Prerequisite:</td>
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<td>Human Learning (EW 1).</td>
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</table>

**see Educational Science Teaching Diploma**

### Subject Didactics in Chemistry

**Important Notice: Enrolment in the courses of this category is only possible if no more than 12 CP of potential additional requirements have to be acquired.**

<table>
<thead>
<tr>
<th>Number</th>
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<td>Mentored Work Subject Didactics Chemistry A</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>A. Baertsch</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 503 of 2416
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

**Abstract**

The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

**Content**

Thematic Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Lecture notes

Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.

Literature

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

**529-0960-00L**

**Subject Didactics Chemistry**

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

**Objective**

The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

**Content**

Thematic Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Lecture notes

Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.

Literature

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

**529-0950-00L**

**Introductory Internship Chemistry**

Simultaneous enrolment in Introductory Internship Chemistry - course 529-0966-00L - is compulsory.

**Abstract**

Implementing findings from research into teaching and learning for chemistry lessons and coverage of subject-specific teaching and learning specialities.

**Objective**

The students have basic subject didactic knowledge for teaching chemistry at a secondary school. They are able to design lessons that are effective for learning, actively involve students in lessons, explain challenging concepts simply, use experiments for theory and reflect on teaching.

**Content**

Schwerpunkte im ersten Studiensemester bilden die folgenden Themen:
- Auswahl: gymnasiumsrelevanter Lerninhalt, didaktische Vereinfachung, Modell und chemischen Formeln zur Beschreibung von Aufbau und Umwandlung der Substanzen
- Wechselspiel zwischen Beobachtung in der realen Welt und Deutung auf Modell-Ebene, Skizzen entwerfen und zur Erklärung von Reaktionen nutzen
- Chemie im 8. Schuljahr: Das Teilchenmodell erklärt viele Phänomene im Anfangsunterricht, Atommodelle und chemische Bindung: Radioaktivität und Kernspaltung
- Struktur und Eigenschaft
- Auswahl: Konzeption, Vorbereitung, Durchführung, Einbettung und Auswertung von Demonstrations-Experimenten
- E. Rossa: Chemie-Didaktik, Cornelsen Verlag, 2015

**Prerequisites / notice**

Der Chemieunterricht am Gymnasium soll einerseits grundlegende chemische Kenntnisse für den Alltag vermitteln und andererseits auf ein naturwissenschaftlich orientiertes Hochschulstudium vorbereiten. Diese beiden Ziele sind im Unterricht gleichermaßen zu berücksichtigen.

Da viele Lerninhalte sequentiell und einander benützend strukturiert sind, ist dem logischen Aufbau des Unterrichts besonderes Augenmerk zu schenken. Dies bedingt eine feine Abstimmung von fachlichen Inhalten und didaktischen Methoden auf die kognitive Leistungsfähigkeit der Lernenden.

Anhand der Diskussion bewährter Beispiele und dem Entwurf eigener Unterrichtsbausteine soll die zukünftige Lehrperson befähigt werden, einen den spezifischen Rahmenbedingungen angepassten Unterricht zu entwickeln, der diesem hohen Qualitätsanspruch genügt.

**Professional Training in Chemistry**

Important Notice: Enrolment in the courses of this category is only possible if no more than 12 CP of potential additional requirements have to be acquired.
Simultaneous enrolment in Subject Didactics Chemistry I
- course 529-0950-00L - is compulsory.

Abstract
During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.

Objective

Content
Das Einführungspraktikum gibt den Studierenden Einblick in den Berufstätigkeit einer Lehrperson.

Literature
Wird von der Praktikumslehrperson bestimmt.

Prerequisites / notice
Das Einführungspraktikum findet an einem Gymnasium der Deutschschweiz statt.

529-0964-00L Teaching Internship Chemistry ■ O 8 credits 17P A. Baertsch

Abstract
The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contributions.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Literature
Wird von der Praktikumslehrperson bestimmt.

Prerequisites / notice
Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.

529-0955-00L Professional Exercises: Experiments in Teaching Chemistry ■ O 2 credits 4V A. Baertsch

Abstract
This course unit introduces students to the technique of conducting experiments in chemistry lessons. It covers didactic, technical, safety-related and presentation aspects.

Objective
Students can
- demonstrate experiments safely and convincingly
- explain observations in a level-appropriate manner
- use experiments to support theory
- know why experiments need to be tested before demonstration
- know some standard experiments
- develop own experiments

Content
Schwerpunkte bilden die folgenden Themen:
- Theoretische Einführung
- Merkmale für ein sicheres Experimentieren
- Die Studierenden erproben und demonstrieren bereitstehende Experimente
- Experimente mit einer Skizze festhalten
- Auf Basis der Literatur ein Experiment selbständig ausarbeiten, dokumentieren und vorführen
- Experimente in den Unterricht einbetten
- Aufgaben zur Auswertung entwerfen

Literature

Prerequisites / notice
Experimentenkurs zum Lehrdiplom in Chemie, der zusammen mit “Fachdidaktik Chemie 1” im Herbstsemester bzw. im Frühlingsemester des nachfolgenden Semesters bestimmt wird. Die Prüfung für die Diplomprüfung ist die zusammen mit den ECTS-Punkten für die “Fachdidaktik Chemie 1” – Voraussetzung für die Zulassung zur “Fachdidaktik Chemie 2” im Frühlingsemester.

Blockveranstaltung mit Anwesenheitspflicht an einem Gymnasium in Zürich.

529-0968-00L Examination Lesson I Chemistry ■ O 1 credit 2P A. Baertsch

Simultaneous enrolment in “Examination Lesson II Chemistry” (529-0968-00L) is compulsory.

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective
On the basis of a specified topic, the candidate shows that they are in a position
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.
Ausgewählte Artikel aus der Primärliteratur werden vorgestellt, kommentiert und zur Lektüre empfohlen.

A. Togni

Lecturers
Type
ECTS

Dokument: Schriftliche Vorbereitung für Prüfungslektionen.https://www.ethz.ch/content/dam/ethz/main/education/didaktische-

On the basis of a specified topic, the candidate shows that they are in a position

Hours
Mentored Work Specialised Courses in the Respective

Title
Folien und ausgewählte Literatur werden zur Verfügung gestellt.

A. Baertsch

Content of the four modules:

The aim is for the students

Examination Lesson II Chemistry

Simultaneous enrolment in "Examination Lesson I Chemistry" (529-0968-01L) is compulsory.

Objective
On the basis of a specified topic, the candidate shows that they are in a position

- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Content

Lecture notes
Dokument: Schriftliche Vorbereitung für Prüfungslektionen.https://www.ethz.ch/content/dam/ethz/main/education/didaktische-

Prerequisites / notice
Nach Abschluss der übrigen Ausbildung.

529-0968-02L Examination Lesson II Chemistry ■

Will mark the conclusion of the teacher training program in Chemistry.

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.


Number
Title
Type
ECTS
Hours
Lecturers

529-0962-00L Fundamental Aspects of Chemistry with an Educational Focus B
Mentored Work with an Educational Focus Chemistry B for Teaching Diploma.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module CHE406 at UZH.
Examination Registration only at ETH.

Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Abstract
Selected topics in general chemistry:
1) The language of chemistry
2) Chirality and stereochemistry
3) Oxidation of water
4) Chemistry of the atmosphere

Objective
In this course, participants acquire extended and more in-depth knowledge of selected chemistry topics. The selection is based to a large extent on the partial aspects of chemistry that are typically taught at high school. By gaining a broader understanding, teachers are put in a position where they can comprehend the topics that are to be taught in a wider and, to some extent, unconventional context and critically process these in respect of their teachability and learnability. At the same time, interrelationships between the classical sub-disciplines of chemistry are highlighted, along with the unique features of chemistry as one of the central natural sciences.

Content
Content of the four modules:
1) The language of chemistry: Concepts, formulas, aesthetics, and philosophical aspects
2) Chirality and stereochemistry: Selected aspects, origin of biomolecular chirality, inorganic chemistry
3) Oxidation from Photosystem II to biomimetic models
4) Chemistry of the atmosphere

Lecture notes
Folien und ausgewählte Literatur werden zur Verfügung gestellt.

Literature
Ausgewählte Artikel aus der Primärliteratur werden vorgestellt, kommentiert und zur Lektüre empfohlen.

Prerequisites / notice
FV A (gelesen im Frühjahrsemester) und FV B (gelesen im Herbstsemester) bauen nicht aufeinander. Die Reihenfolge der Belegung ist somit indifferent.

529-0962-01L Mentored Work Specialised Courses in the Respective Subject with an Educational Focus Chemistry B ■

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
The aim is for the students

- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.
Thematische Schwerpunkte:


Lernformen:


Lecture notes

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

529-0961-01L Mentored Work Specialised Courses in the Respective O Subject with an Educational Focus Chemistry A ■ 2 credits 4A A. Baertsch

Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective

- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content

Thematische Schwerpunkte:


Lernformen:


Lecture notes

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Unterrichtspraktikums abgeschlossen werden.

► Compulsory Elective Courses

see Compulsory Elective Courses Teaching Diploma

Chemistry Teaching Diploma - Key for Type

| O   | Compulsory       | E-  | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended | Z   | Courses outside the curriculum |
| W   | Eligible for credits | Dr  | Suitable for doctorate |

Key for Hours

| V   | lecture         | P   | practical/laboratory course |
| G   | lecture with exercise | A   | independent project |
| U   | exercise        | D   | diploma thesis |
| S   | seminar         | R   | revision course / private study |
| K   | colloquium      |     |                           |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Organic Chemistry

529-0233-01L Organic Synthesis: Methods and Strategies W+ 6 credits 3G E. M. Carreira
Abstract
The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.
Objective
Content
Prerequisites / notice
OC I-IV
Fostered competencies

529-0241-10L Selectivity in Organic Synthesis W+ 6 credits 3G J. W. Bode
Abstract
Fundamentals of selective organic reactions, including current and historical examples of enantioselectivity, regioselectivity, chemoselectivity. Further aspects include recent developments in catalysis, strategies and tools for selective organic synthesis.
Objective
Understanding and explaining the origin of selectivity in organic synthesis and the application of selective organic reactions to the construction of complex organic and biological molecules.
Content
Lecture notes
will be provided in class and online
Literature
Suggesting Textbooks
Fostered competencies

Physical Chemistry

529-0433-01L Advanced Physical Chemistry: Statistical Thermodynamics W+ 6 credits 3G R. Riek, J. Richardson
Abstract
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.
Concepts and Theories

All technologies used for the experiments will be explained to the students in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

Further literature will be indicated in the distributed script.


- For more information, see also http://www.kast.ethz.ch/teaching.html or contact P. Kast directly (HCI F 333, Tel. 044 632 29 08, kast@org.chem.ethz.ch).

- This laboratory course will involve experiments that require a tight schedule and (sometimes) long (!) working days.
- The projects of this course are tightly linked to the ones of the Biology BSc course "529-0739-01 Biological Chemistry B: New Enzymes from Directed Evolution Experiments", which takes place as a block course during the month of November. There will be joint lectures for the participants of both courses during that time. The teaching language is English.
- Critical Thinking

- Social Competencies
  - Communication

- Personal Competencies
  - Creative Thinking

- Prerequisites / notice
  - Candidates must inquire with P. Kast no later than September 1st whether course will take place (no self-enrollment!

- Content
  - This class conducts and supports experiments for a specifically designed genuine research project. We will carry out biological-chemical enzyme evolution experiments using molecular genetic mutation technologies and in vivo selection in recombinant bacterial strains.

- Objective
  - All technologies used for the experiments will be explained to the students in practice with the goal that they will be able to independently apply them for the course project and in future research endeavors. After the course, an individual report about the results obtained has to be prepared.

- Literature
  - The necessary documents and protocols will be distributed to the participants during the course.

- Lectures

- Prerequisites / notice
  - This laboratory course will involve experiments that require a tight schedule and (sometimes) long (!) working days.
  - The projects of this course are tightly linked to the ones of the Biology BSc course "529-0739-01 Biological Chemistry B: New Enzymes from Directed Evolution Experiments", which takes place as a block course during the month of November. There will be joint lectures for the participants of both courses during that time. The teaching language is English.
  - The number of participants for the laboratory class is limited. It is mandatory to sign up for the course directly with P. Kast no later than September 1, prior to the start of the fall semester. Until then it will be decided whether the course will take place.
  - A valid registration is considered a commitment for attendance of the entire semester course, as involved materials will be ordered for all participants of both courses during that time. The teaching language is English.

- Objective
  - In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.

- Lecture notes
  - See homepage of the lecture.

- Literature
  - See homepage of the lecture.
**Master's Thesis**

<table>
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<th>Lecturers</th>
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<td>Master's Thesis</td>
<td>O</td>
<td>25 credits</td>
<td>54D</td>
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</table>

Only students who fulfill the following criteria are allowed to begin with their Master's thesis:

a. successful completion of the Bachelor's programme;
b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.

Duration of the Master's Thesis 20 weeks.

**Electives**

Students are free to choose from a range of D-CHAB chemistry courses appropriate to their level of study (please note admission requirements). In case of doubt, contact the student administration.

**Inorganic Chemistry**

<table>
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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</table>

**Abstract**

General bonding concepts

AIM and ELF as descriptors of electronic structures

GCMT model, carbenes and carbene analogues, homo and heteronuclear unsaturated bonds

Electron precise cluster, electron deficient cluster, and special cluster

**Objective**

The course starts with an introduction into general concepts allowing to understand why main group element and transition metal compounds from the higher periods show different properties when compared to their lighter congeners. The Atom in Molecule (AIM) Theory and Electron Localization Function (ELF) will be introduced as means to interpret the electron density distribution in molecules. Carbenes and carbene analogues will be discussed as building blocks for compounds with unsaturated bonds which in turn may serve as precursors to inorganic polymers.

Electron counting rules allow to distinguish different type of clusters which can be divided into electron precise cluster, various electron deficient cluster (for example Wade-Mingos-Cluster), and special cluster.

An introduction into general concepts for syntheses and analyses of inorganic polymers will be given. Specifically, polysilanes, polysiloxanes, and polyphosphazenes will be discussed and possible applications of these polymers will be highlighted.

Recent literature will be provided and discussed jointly by the participants of the course (flipped classroom).

The main goal of the lecture is to provide a general understanding of the current literature in the field of modern inorganic chemistry with respect to building blocks used for the synthesis of cluster, polymers, and materials.

**Lecture notes**

A handout of the presented material will be distributed to the participants of the course. Articles from recent literature will be provided and discussed in the course.

**Literature**

Orginal literature is indicated in the course material.

Basis for the understanding of this lecture are the courses Allgemeine Chemie 1&2, and Anorganische Chemie 1: Übergangsmetallchemie.

**Organic Chemistry**

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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**Fostered competencies**

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</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 510 of 2416
Transition Metal Catalysis: From Mechanisms to Applications

Abstract
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint.

Objective
Understanding and critical evaluation of current research in transition metal catalysis. Design of mechanistic experiments to elucidate reaction mechanisms. Synthetic relevance of transition metal catalysis. Students will also learn about writing an original research proposal during a workshop.

Content
Detailed discussion of selected modern transition metal catalyzed reactions from a synthetic and mechanistic viewpoint. Synthetic applications of these reactions. Introduction and application of tools for the elucidation of mechanisms. Selected examples of topics include: C-H activation, C-O activation, C-C activation, redox active ligands, main group redox catalysis, bimetallic catalysis.

Lecture notes
Lecture slides will be provided online. A Handout summarizing important concepts in organometallic and physical organic chemistry will also be provided. Useful references and handouts will also be provided during the workshop.

Literature
Primary literature and review articles will be cited during the course.

The following textbooks can provide useful support for the course:

Prerequisites / notice
Required level: Courses in organic and physical chemistry (kinetics in particular) of the first and second year as well as ACIII.

Organic Synthesis: Methods and Strategies

Abstract
The complex relation between structural analysis, methods leading to desired transformations, and insight into reaction mechanisms is exemplified. Relations between retrosynthetic analysis of target structures, synthetic methods and their combination in a synthetic strategy.

Objective

Content
The following textbooks can provide useful support for the course:

Literature

Prerequisites / notice
Special requirement: each participant will have to come up with an independent research proposal to be presented orally (or handed in in written form) at the end of the semester. A dedicated workshop will be organized in the middle of the semester to introduce the students to the process of proposal writing and presentation.
### Fostered competencies
- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Analytical Competencies: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed
- **Method-specific Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
- **Social Competencies**
  - Negotiation: not assessed
- **Personal Competencies**
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed

### Literature
- **Nucleic Acids and Carbohydrates**

### Lecture notes
- Citations from the original literature relevant to the individual lectures will be assigned weekly.

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### Physical Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0433-01L</td>
<td>Advanced Physical Chemistry: Statistical Thermodynamics</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>R. Riek, J. Richardson</td>
</tr>
<tr>
<td></td>
<td>Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.</td>
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<td></td>
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</tbody>
</table>

- **Lecture notes**
  - See homepage of the lecture.

- **Prerequisites / notice**
  - Chemical Thermodynamics, Reaction Kinetics, Molecular Quantum Mechanics and Spectroscopy; Mathematical Foundations (Analysis, Combinatorial Relations, Integral and Differential Calculus)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0443-01L</td>
<td>Advanced Magnetic Resonance</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>G. Jeschke, A. Barnes</td>
</tr>
<tr>
<td></td>
<td>Does not take place this semester.</td>
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</tbody>
</table>
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. This semester, the lecture will introduce and discuss the dynamics of electron-nuclear spin systems and experiments based on hyperfine interactions in electron paramagnetic resonance (EPR) spectroscopy and dynamic nuclear polarization (DNP) for sensitivity enhancement in NMR.

The course aims at enabling students to understand and design experiments that are based on hyperfine coupling between electron and nuclear spins. This includes analytical and numerical treatment of spin dynamics as well as instrumental aspects. Additionally, students will learn how to use hyperfine couplings to increase sensitivity in solid state NMR via dynamic nuclear polarization (DNP), with an emphasis on the instrumentation required to perform DNP with magic angle spinning (MAS) NMR.

The course starts with a recapitulation of density operator and product operator formalism with special emphasis on electron-nuclear spin systems in the solid state. We then treat basic phenomena, such as passage effects, avoided level crossings, and hyperfine decoupling. Based on these foundations, we discuss polarization transfer from the electron to the nuclear spin and back, as well as spin diffusion as a mechanism for polarization of nuclei beyond the immediate vicinity of the electron spin. The second half of the course will cover dynamic nuclear polarization (DNP), with a focus on instrumentation required to perform pulsed DNP with magic angle spinning (MAS) at ultra-high magnetic fields. A review of salient interactions in the NMR solid state NMR Hamiltonian, DNP mechanisms, and electron decoupling with MAS will motivate discussions of technology development. Specific techniques to be covered include, but are not limited to, frequency agile gyrotron oscillators, corrugated waveguides, microwave lenses, strategies for creating pulsed and frequency chirped microwaves, spherical MAS rotors and supporting stators, high temperature superconductor (HTS) based compact magnets, and radio-frequency circuits for multinuclear spin control and detection.

Prerequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book “Spin Dynamics” by Malcolm Levitt.

A script which covers the topics will be distributed in the lecture and will be accessible through the course Moodle.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0027-00L</td>
<td>Advanced Magnetic Resonance - Solid State NMR</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. Ernst</td>
</tr>
</tbody>
</table>

Abstract:
The course is for advanced students and introduces and discusses the theoretical foundations of solid-state nuclear magnetic resonance (NMR).

Objective:
The aim of the course is to familiarize the students with the basic concepts of modern high-resolution solid-state NMR. Starting from the mathematical description of spin dynamics, important building blocks for multi-dimensional experiments are discussed to allow students a better understanding of modern solid-state NMR experiments. Particular emphasis is given to achieving high spectral resolution.

Content:
The basic principles of NMR in solids will be introduced. After the discussion of basic tools to describe NMR experiments, basic methods and experiments will be discussed, e.g., magic-angle spinning, cross polarization, decoupling, and recoupling experiments. Such basic building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

Lecture notes:
A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.ssnmr.ethz.ch/education/

Prerequisites:
Prerequisite: A basic knowledge of NMR, e.g. as covered in the Lecture Physical Chemistry IV, or the book by Malcolm Levitt.
Nanotechnology is the basis of many main technological innovations of the 21st century. After more than twenty years of research, nanotechnologies are now increasingly employed for commercial use: they are used in hundreds of everyday consumer products, such as cosmetics, food, automotive, electronics and medical products. Nanoparticles can contribute to stronger, lighter, cleaner, smarter, better, etc. products.

Besides these positive effects, relatively little is still known about potential health and environmental effects and risks of such small nano-sized particles. Therefore, a lot of different industry customers are forced nowadays to monitor and regulate the size and concentration of nanoparticles in their nano-enabled products.

Above and beyond these regulatory requirements, most industries employing nanoparticles need to be able to online measure nanoparticles to meet their requirements towards quality control and production efficiency. All these requirements demand new precise, accurate, fast and innovative analysis methods to fully characterize nanoparticles in real-time and during the manufacturing process.

### Biological Chemistry

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0733-02L</td>
<td>Chemical Biology and Synthetic Biochemistry</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>K. Lang</td>
</tr>
</tbody>
</table>

**Abstract**

Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

**Objective**

After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.

**Content**

principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries);

principles of genetic code expansion (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing);

chemical biology of ubiquitin and targeted protein degradation

**Lecture notes**

Lecture notes will be provided

**Literature**

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

**Prerequisites / notice**

Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

### Chemical Aspects of Energy

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<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>A. Steinfeld, E. I. M. Casati</td>
</tr>
</tbody>
</table>

**Abstract**

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

**Objective**

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

**Lecture notes**

Lecture Notes containing copies of the presented slides.

**Prerequisites / notice**

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

### Chemical Crystallography

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0029-01L</td>
<td>Structure Determination</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>M. D. Wörle, N. Trapp</td>
</tr>
</tbody>
</table>

**Abstract**

Advanced X-ray crystal structure analysis

**Objective**

To gain a deeper understanding of crystal structure determination principles and practice by X-ray diffraction and the evaluation of results.

**Content**

Review of principles of diffraction and instrumentation, unit cells, lattices, and symmetry. Inorganic structural chemistry: sphere packings, ionic crystals, covalent networks, intermetallic compounds. Overview of powder diffraction and application of crystal chemistry for structure analysis of polycrystalline phases. Working safely with X-rays, crystal growth, selection and mounting, data collection strategies, data reduction, corrections for absorption, extinction and Lp, advanced structure solution theory and techniques: Patterson function, heavy atom technique, Fourier methods, direct methods. Structure modeling and refinement, disorder, twinning, false symmetry, interpretation of anisotropic shift parameters. Determination of absolute configuration, interpretation of results and scope of chemically useful information, validation and publication of results, critical evaluation of published crystal structures.

**Lecture notes**

Information and exercise sheets will be distributed in loose form.
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to

**Main references**


(2) J.D. Dunitz, "X-ray Analysis and the Structure of Organic Molecules", 1995, Verlag HCA.

**Additional literature**


**Prerequisites / notice**

Students will conduct the computational exercises and examples of structure solution and refinement on personal computers.

Prerequisite: Principles of Crystal Structure Determination (529-0039-00L).

### Chemical Technology

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0180-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>M. Fussenegger</td>
</tr>
</tbody>
</table>

**Abstract**

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Objective**

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

**Content**


**Lecture notes**

Handout during the course.

### Computational Chemistry

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0003-01L</td>
<td>Advanced Quantum Chemistry</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>M. Reiher, A. Baiardi</td>
</tr>
</tbody>
</table>

**Abstract**

Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer. Examples are:

* Operators derived from principles of relativistic quantum mechanics
* Relativistic effects + methods of relativistic quantum chemistry
* Open-shell molecules + spin-density functional theory
* New electron-correlation theories

**Objective**

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

**Content**

1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group
9) Quantum chemistry without the Born-Oppenheimer approximation

**Lecture notes**

A set of detailed lecture notes will be provided, which will cover the whole course.
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, ...).

ECTS 6 credits

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Note also the standard textbooks:

A) A. Szabo, N.S. Ostlund. Verlag. Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Literature

2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997
[english version available: F. Schwabl, Advanced Quantum Mechanics]
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992
http://pubs.rsc.org/en/Content/ArticleLanding/2011/CP/c1cp10188b
http://pra.aps.org/abstract/PRA/v83/i5/e052512

Note also the standard textbooks:

A) A. Szabo, N.S. Ostlund. Verlag. Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

529-0004-01L Classical Simulation of (Bio)Molecular Systems W 6 credits 4G P. H. Hünenberger, J. Dolenc, S. Riniker

Objective

Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature

See: www.csms.ethz.ch/education/CSBMS

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

Materials

Number Title Type ECTS Hours Lecturers

327-0703-00L Electron Microscopy in Material Science W 4 credits 2V+2U S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze

Abstract

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content

This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Lecture notes

will be distributed in English

Literature

Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

402-0468-15L Nanomaterials for Photonics W 6 credits 2V+1U R. Grange

Abstract

The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based,...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures,...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

Objective

The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...), and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 516 of 2416
1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices
   
2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light
   
3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field; electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

Environmental Chemistry

<table>
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<tr>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0745-01L</td>
<td>General and Environmental Toxicology</td>
<td>W</td>
<td>6 credits</td>
<td>3V</td>
<td>M. Arand, H. Nägele</td>
</tr>
</tbody>
</table>

Abstract
Toxicokinetic and toxicodynamic aspects of xenobiotic interactions with cellular structures and mechanisms. Toxic responses at the level of organs (immune-, neuro-, reproductive and genotoxicity) and organisms. Introduction into developmental toxicology and ecotoxicology.

Objective
Understanding the impact of chemicals on biological systems; evaluation of the effects from different biomedical perspectives.

Content
Explanation of important interactions between xenobiotic chemicals and cellular structures such as membranes, enzymes, and nucleic acids. Relevance of intake, distribution, excretion, and biochemical transformation processes. Relevance of mixtures. Explanation of important modes of toxic action such as immuno toxicity, neurotoxicity, reproduction toxicity, genotoxicity based on examples of certain xenobiotics and their effects on important organs.

Economics and Technology Management

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0389-00L</td>
<td>Technology and Innovation Management</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Brusoni, A. Zeijen</td>
</tr>
</tbody>
</table>

Lecture notes
Course material will be handed out as the lectures progress

Literature
Textbooks of pharmacology and toxicology (cf. list in course material)

Prerequisites / notice
Educational basis: basic chemistry, biology and biochemistry

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 517 of 2416
## Principles of Microeconomics

This course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

### Content

This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

### Literature

Slides will be available on the Moodle page

Readings will be available on the Moodle page

The course content and methods are designed for students with some background in management and/or economics

### Prerequisites / notice

The course content and methods are designed for students with some background in management and/or economics

### Fostered competencies

**Subject-specific Competencies**
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - assessed

**Personal Competencies**
- Critical Thinking
  - assessed

### 363-0565-00L Principles of Macroeconomics

**Abstract**

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective**

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

**Content**

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

**Lecture notes**

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

**Literature**

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

### Fostered competencies

**Subject-specific Competencies**
- Concepts and Theories
  - assessed
- Techniques and Technologies
  - not assessed

**Method-specific Competencies**
- Analytical Competencies
  - assessed
- Decision-making
  - not assessed
- Media and Digital Technologies
  - not assessed
- Problem-solving
  - assessed
- Project Management
  - not assessed

**Social Competencies**
- Communication
  - not assessed
- Cooperation and Teamwork
  - not assessed
- Customer Orientation
  - not assessed
- Leadership and Responsibility
  - not assessed
- Self-presentation and Social Influence
  - assessed
- Sensitivity to Diversity
  - not assessed
- Negotiation
  - not assessed

**Personal Competencies**
- Adaptability and Flexibility
  - not assessed
- Creative Thinking
  - not assessed
- Critical Thinking
  - assessed
- Integrity and Work Ethics
  - not assessed
- Self-awareness and Self-reflection
  - not assessed
- Self-direction and Self-management
  - not assessed

### 363-0503-00L Principles of Microeconomics

**Abstract**

The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

**GESS (Science in Perspective):** This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
The learning objectives of the course are:

(1) Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.

The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a fair distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programmes. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

The book can also be used for the course "Principles of Macroeconomics" (Sturm)

Complementary:

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Inorganic Chemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>

Abstract
- General bonding concepts
- AIM and ELF as descriptors of electronic structures
- GCMT model, carbenes and carbene analogues, homo and heteronuclear unsaturated bonds
- Electron precise cluster, electron deficient cluster, and special cluster
- General concepts and definitions of inorganic polymers, polylines, polysiloxanes, polyphosphazenes

Objective
- The course starts with an introduction into general concepts allowing to understand why main group element and transition metal compounds from the higher periods show different properties when compared to their lighter congeners. The Atom in Molecule (AIM) Theory and Electron Localization Function (ELF) will be introduced as means to interpret the electron density distribution in molecules.
- Carbenes and carbene analogues will be discussed as building blocks for compounds with unsaturated bonds which in turn may serve as precursors to inorganic polymers.
- Electron counting rules allow to distinguish different type of clusters which can be divided into electron precise cluster, various electron deficient cluster (for example Wade-Mingos-Cluster), and special cluster.
- General concepts and definitions of inorganic polymers, polylines, polysiloxanes, polyphosphazenes will be discussed and possible applications of these polymers will be highlighted.

Recent literature will be provided and discussed jointly by the participants of the course (flipped classroom).

The man goal of the lecture is to provide a general understanding of the current literature in the field of modern inorganic chemistry with respect to building blocks used for the synthesis of cluster, polymers, and materials.
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. This semester, the lecture will introduce and discuss the dynamics of electron-nuclear spin systems and experiments based on hyperfine interactions in electron paramagnetic resonance (EPR) spectroscopy and dynamic nuclear polarization (DNP) for sensitivity enhancement in NMR.

**Objective**
The course aims at enabling students to understand and design experiments that are based on hyperfine coupling between electron and nuclear spins. This includes analytical and numerical treatment of spin dynamics as well as instrumental aspects. Additionally, students will learn how to use hyperfine couplings to increase sensitivity in solid state NMR via dynamic nuclear polarization (DNP), with an emphasis on the instrumentation required to perform DNP with magic angle spinning (MAS) NMR.

**Content**
The course starts with a recapitulation of density operator and product operator formalism with special emphasis on electron-nuclear spin systems in the solid state. We then treat basic phenomena, such as passage effects, avoided level crossings, and hyperfine decoupling. Based on these foundations, we discuss polarization transfer from the electron to the nuclear spin and back, as well as spin diffusion as a mechanism for polarizing nuclear spins beyond the immediate vicinity of the electron spin. The second half of the course will cover dynamic nuclear polarization (DNP), with a focus on instrumentation required to perform DNP with magic angle spinning (MAS) at ultra-high magnetic fields. A review of salient interactions in the NMR solid state NMR Hamiltonian, DNP mechanisms, and electron decoupling with MAS will motivate discussions of technology development. Specific technologies to be covered include, but are not limited to, frequency agile gyrotron oscillators, corrugated waveguides, microwave lenses, strategies for creating pulsed and frequency chirped microwaves, spherical MAS rotors and supporting stators, high temperature superconductor (HTS) based compact magnets, and radio-frequency circuits for multinuclear spin control and detection.

Prerequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book “Spin Dynamics” by Malcolm Levitt.

**Lecture notes**
A script which covers the topics will be distributed in the lecture and will be accessible through the course Moodle.
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

The underlying lecture (529-0051-00L) is offered in autumn semester but only in German.

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications.

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

Lecture notes
Script will be provided for the production price.

Literature
- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995;

Prerequisites / notice
Excercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

529-0058-AAL
Analytical Chemistry II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Enhanced knowledge about the elemental analysis and spectrocopical techniques with close relation to practical applications. This course is based on the knowledge from analytical chemistry I. Separation methods are included.

Objective
Use and applications of the elemental analysis and spectrocopical knowledge to solve relevant analytical problems.

Content
Combined application of spectrocopical methods for structure determination, and practical application of element analysis. More complex NMR methods: recording techniques, application of exchange phenomena, double resonance, spin-lattice relaxation, nuclear Overhauser effect, applications of experimental 2d and multipulse NMR spectroscopy, shift reagents. Application of chromatographic and electrophoretic separation methods: basics, working technique, quality assessment of a separation method, van-Deemter equation, gas chromatography, liquid chromatography (HPLC, ion chromatography, gel permeation, packing materials, gradient elution, retention index), electrophoresis, electroosmotic flow, zone electrophoresis, capillary electrophoresis, isoelectrical focussing, electrochromatography, 2d gel electrophoresis, RDS-labelling, field flow fractionation, enhanced knowledge in atomic absorption spectroscopy, atomic emission spectroscopy, X-ray fluorescence spectroscopy, ICP-OES, ICP-MS.

Literature

Prerequisites / notice
None.

529-0132-AAL
Inorganic Chemistry III: Organometallic Chemistry and Homogeneous Catalysis
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbonylation, C-C bond-forming and related reactions.

Objective
Towards an understanding of the fundamental coordination-chemical and mechanistic aspects of transition-metal chemistry relevant to homogeneous catalysis.

Content
Fundamental aspects of the organometallic chemistry of the transition elements. Mechanistic homogeneous catalysis including oxidative additions, reductive eliminations and insertion reactions. Catalytic hydrogenation, carbonylation, C-C bond-forming and related reactions.
Literature


Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Problem-solving</td>
<td>Creative Thinking</td>
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<tr>
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<tr>
<td>assessed</td>
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<td>Critical Thinking</td>
</tr>
</tbody>
</table>

529-0431-AAL Physical Chemistry III: Molecular Quantum Mechanics E- 4 credits 9R F. Merkt

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

This course does not offer a lecture of its own but it is linked to the course 529-0431-00L.

Abstract
Postulates of quantum mechanics, operator algebra, Schrödinger's equation, state functions and expectation values, matrix representation of operators, particle in a box, tunneling, harmonic oscillator, molecular vibrations, angular momentum and spin, generalised Pauli principle, perturbation theory, electronic structure of atoms and molecules, Born-Oppenheimer approximation.

Objective
This is an introductory course in quantum mechanics. The course starts with an overview of the fundamental concepts of quantum mechanics and introduces the mathematical formalism. The postulates and theorems of quantum mechanics are discussed in the context of experimental and numerical determination of physical quantities. The course develops the tools necessary for the understanding and calculation of elementary quantum phenomena in atoms and molecules.

Content

Literature

529-0432-AAL Physical Chemistry IV: Magnetic Resonance E- 4 credits 9R G. Jeschke, M. Ernst

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Theoretical foundations of magnetic resonance (NMR,EPR) and selected applications.

Objective
Introduction to magnetic resonance in isotropic and anisotropic phase.

Content
The course gives an introduction to magnetic resonance spectroscopy (NMR and EPR) in liquid, liquid crystalline and solid phase. It starts from a classical description in the framework of the Bloch equations. The implications of chemical exchange are studied and two-dimensional exchange spectroscopy is introduced. An introduction to Fourier spectroscopy in one and two dimensions is given and simple 'pulse trickery' is described. A quantum-mechanical description of magnetic resonance experiments is introduced and the spin Hamiltonian is derived. The chemical shift term as well as the scalar, dipolar and quadrupolar terms are discussed. The product-operator formalism is introduced and various experiments are described, e.g. polarization transfer. Applications in chemistry, biology, physics and medicine, e.g. determination of 3D molecular structure of dissolved molecules, determination of the structure of paramagnetic compounds and imaging (MRI) are presented.

Lecture notes
handed out in the lecture (in english)

Literature
see http://www.ssnmr.ethz.ch/education/PC_IV_Lecture

529-0129-AAL Inorganic and Organic Chemistry II E- 11 credits 16R V. Mougel

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

This course does not offer a lecture of its own but it is linked to the course 529-0129-00L.

Abstract
Introduction to the experimental methods of Inorganic Chemistry

Objective
The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc.. The synthesis, characterization and analysis of inorganic compound are a main topic. Emphasis is given to scientific writing (experiment reports).

Content
Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra.

Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Lecture notes
A manual is distributed in the teaching laboratory.
Prerequisites:
- Practical Course General Chemistry (1. Semester, 529-0011-04)
- Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)
- Attendance of Course Inorg. Chemistry I (3. Sem., 529-0121)

If necessary, access priority will be settled according to the results of the first-year examinations.
Safety concept: [https://chab.ethz.ch/studium/bachelor1.html](https://chab.ethz.ch/studium/bachelor1.html)

### Chemistry Master - Key for Type

<table>
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<th>Key</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
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<tr>
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<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### ECTS

- **Special students and auditors need special permission from the lecturers.**
Chemical and Bioengineering Master

Core Subjects

Biochemical Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>529-0837-01L</td>
<td>Biomicrofluidic Engineering</td>
<td>W+</td>
<td>6</td>
<td>3G</td>
<td>A. de Mello</td>
</tr>
</tbody>
</table>

**Abstract**

Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

**Objective**

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

**Content**

Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Pécellet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small Volume Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
    Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.
In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that levers on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the biological properties and functions of biomolecular condensates in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present a milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.

The presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature. As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

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Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

Abstract
The 'Chemical Product Design' course teaches students quantitative concepts to analyze, select and transform theoretical concepts from chemistry and engineering into valuable real-world products. Basic chemistry and chemical engineering knowledge is required (Diffusion, Thermodynamics, Kinetics,...).

Objective
This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g. responsive building materials; personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or compound, and the necessary steps to pursue the resulting project within an entrepreneurial environment. We therefore extend the questions of process design ('how do we make something?') to the question of 'what should we make?'

Content
Part A: The 'Chemical Product Design' course starts with discussing questions along, 'What is a chemical product, and why do people pay for it? How does a given compound in a specific setting provide a service?' We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation unit as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

Students are expected to actively develop chemical products along the course. Contributions will be made individually, or in small groups, where a larger topic is studied.

Literature


Prerequisites / notice
Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics,...).

Process Design

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-0643-01L</td>
<td>Process Design and Development</td>
<td>W+</td>
<td>6</td>
<td>3G</td>
<td>G. Guillén Gosálbez</td>
</tr>
</tbody>
</table>

Abstract
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

Objective
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stage of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

Content
Process creation: heuristics vs. mathematical programming.
Heuristics for reaction and separation operations, heat transfer and pressure change.
Introduction to optimization in process engineering and the modeling software GAMS.
Process economic evaluation: equipment sizing and costing, time value of money, cash flow calculations.
Process integration: sequencing of distillation columns using mixed-integer linear programming (MILP), and synthesis of heat exchanger networks using mixed-integer nonlinear programming (MINLP).
Batch processes: scheduling, sizing, and inventories.
Principles of molecular design using mixed-integer programming.

Lecture notes
no script

Literature
Main books

Other references

Prerequisites / notice
Prerequisite: Basic knowledge on unit operations, mainly reaction engineering and distillation. It is recommended that the student takes the module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

529-0613-01L Process Simulation and Flowsheeting W+ 6 credits 3G G. Guillén Gosálbez

Abstract
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheeting and optimization problems.
Objective
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Content
Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

Literature
An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice
A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

★★ Catalysts and Separation

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0927-00L</td>
<td>Rate-Controlled Separations in Fine Chemistry</td>
<td>W+</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>M. Mazzotti, V. Becattini</td>
</tr>
</tbody>
</table>

Abstract
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.

Objective
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

Content
The class covers separation techniques that are central in the purification and downstream processing of chemicals and bio-pharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

Prerequisites / notice
Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)
The aspects described above will be demonstrated through industrially-relevant examples such as:
- Simulate and optimize a chemical production process using commercial process simulation software.
- Fostered competencies
- Social Competencies
- Personal Competencies

**Objective**

To accelerate the discovery and implementation of sustainable technologies, this vibrant discipline is constantly refining its design principles, particularly at the nanoscale, a shift facilitated by the availability of increasingly powerful tools that permit the continued development of fundamental knowledge over different time and length scales. During this course, you will learn current concepts for the defossilization of the chemical industry and strategies for achieving this goal from idea to implementation. By introducing topical case studies both in lectures and through a semester project, you will see aspects of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalyst design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

**Content**

The learning objective is to design, simulate and optimize a real (bio-)chemical process from a process systems perspective. Specifically, a commercial process simulation software (Aspen) will be used for the process simulation and optimization. Students have to integrate knowledge and develop engineering thinking and skills acquired in the other courses of the curriculum.

**Evaluate the performance of the production process**
- Students will analyse and understand the degrees of freedom in modelling process units and flowsheets.
- Students will understand the role of process simulators in process creation.
- Students will make design specifications and follow the iterations implemented to satisfy them.
- Students will judge the role of process simulators in equipment sizing and costing and profitability analysis.
- Students will assess the economic performance of the process, including operating costs (OPEX), and capital investment (CAPEX), based on the outcome of the simulation model.
- Students will assess the environmental impact of the production process following the Life Cycle Assessment (LCA) methodology.

**Optimize the design and operating conditions of the production process**
- Students will carry out sensitivity analyses and optimizations considering technical and economic criteria.
- Students will generate process integration alternatives to improve the initial design.
- Students will optimize the production process considering economic and environmental criteria.

**Case Study**

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<th>Hours</th>
<th>Lecturers</th>
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</table>

The learning objective is to design, simulate and optimize a real (bio-)chemical process from a process systems perspective. Specifically, a commercial process simulation software (Aspen) will be used for the process simulation and optimization. Students have to integrate knowledge and develop engineering thinking and skills acquired in the other courses of the curriculum.

**Simulate and optimize a chemical production process using commercial process simulation software.**
- Students will apply a commercial process simulator systematically for process creation and analysis.
- Students will create a process simulation flowsheet for steady-state simulation.

The course material is based on slides and journal articles.

It is assumed that students selecting this course are familiar with basic concepts of chemistry and catalysis (chemistry or chemical engineering background). Other students are welcome to contact us to discuss the requirement for prior knowledge.
Before the case study week, students are encouraged to participate in the exercises of the course “Process Simulation and Flowsheeting” in order to get familiar with the Aspen Plus simulation software (this is highly recommended, but not mandatory). The problem statement and detailed instructions are provided in the project brief made available at the beginning of the case study week.

During the case study week:
- Students work in teams of 4-6 people.
- Students have to pose and solve process equipment and system design related problems.
- Students have to coordinate the activities, the preparation of the written report and the oral presentation.
- Students get support from project assistants and the course supervisor.

The groups deliver the written report on a predefined date.

The students receive the feedback and are asked to implement some changes in their reports.

A final presentation takes place summarizing the main findings of the project.

## Research Project or Industry Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0300-10L</td>
<td>Research Project</td>
<td>W</td>
<td>13</td>
<td>16A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.</td>
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<tr>
<td>Objective</td>
<td>First contact with experimental techniques of chemical engineering in a research group. Critical evaluation and presentation of the results in a scientific report.</td>
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<tr>
<td>Content</td>
<td>This laboratory project is organised during the spring vacation before the sixth semester. The participant can choose his topic from the list of projects suggested. Main emphasis during this research work is to get experience in using different engineering tools and evaluation and the interpretation of the results. Those are presented as a scientific report.</td>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>529-0301-00L</td>
<td>Industry Internship</td>
<td>W</td>
<td>13</td>
<td></td>
<td>Supervisors</td>
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<tr>
<td>Abstract</td>
<td>Internship in industry with a minimum duration of 7 weeks</td>
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<tr>
<td>Objective</td>
<td>The aim of the internship is to make students acquainted with industrial work environments. During this time, they will have the opportunity to get involved in current projects of the host institution.</td>
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<tr>
<td>Content</td>
<td>This laboratory project is organised during the spring vacation before the sixth semester. The participant can choose his topic from the list of projects suggested. Main emphasis during this research work is to get experience in using different engineering tools and evaluation and the interpretation of the results. Those are presented as a scientific report.</td>
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## Master's Thesis

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<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0600-10L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>25</td>
<td>54D</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Title</td>
<td>Only students who fulfill the following criteria are allowed to begin with their Master's thesis:</td>
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<tr>
<td></td>
<td>a. successful completion of the Bachelor's programme;</td>
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<tr>
<td></td>
<td>b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.</td>
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Duration of the Master's Thesis 20 weeks.

## Electives

### Biochemical Engineering

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4</td>
<td>3V</td>
<td>M. Fussenegger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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<tr>
<td>Objective</td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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<tr>
<td>Lecture notes</td>
<td>Handout during the course.</td>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td>Abstract</td>
<td>Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).</td>
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<tr>
<td>Objective</td>
<td>The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.</td>
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</table>
Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the model building, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing large-scale network organization. These include (i) graph theoretical approaches to construct probabilistic (Bayesian) network representations, (ii) structural network analysis based on reaction stoichiometries, (iii) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (iv) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes
http://www.csb.ethz.ch/education/lectures.html


<table>
<thead>
<tr>
<th>Number</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecturer(s)</th>
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</thead>
<tbody>
<tr>
<td>376-1714-00L</td>
<td>Biochemical Materials</td>
<td>W 4 credits</td>
<td>3V K. Maniura, M. Rottmar, M. Zenobi-Wong</td>
</tr>
<tr>
<td>376-1714-01L</td>
<td>Biochemical and Polymer Reaction Engineering</td>
<td>W 6 credits</td>
<td>3G P. Arosio</td>
</tr>
<tr>
<td>529-0615-01L</td>
<td>Biocompatible Materials</td>
<td>W 6 credits</td>
<td>3G P. Arosio</td>
</tr>
<tr>
<td>529-0837-01L</td>
<td>Biomicrofluidic Engineering</td>
<td>W 6 credits</td>
<td>3G A. de Mello</td>
</tr>
</tbody>
</table>

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Diffuse focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
- Handouts are deposited online (moodle).

Literature

Handouts and references therein.

<table>
<thead>
<tr>
<th>Number</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lecturer(s)</th>
<th>Literature</th>
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</thead>
<tbody>
<tr>
<td>529-0837-01L</td>
<td>Biomicrofluidic Engineering</td>
<td>W 6 credits</td>
<td>3G A. de Mello</td>
<td></td>
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</tbody>
</table>

Objective
The aim of the course is to learn how to design microfluidic devices such as microfluidic channels and microfluidic pumps, to produce and manipulate fluids in the microfluidic channel with specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

Content
We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes, Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

Lecture notes
Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html

Additional handout of slides will be provided during the lectures.

Literature
Specific topics covered in the course include, but are not limited to:

1. **Theoretical Concepts**
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. **Microfluidic Device Manufacture**
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. **Electrokinetics**
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. **Mass Transfer Phenomena**
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. **Heat Transfer Phenomena**
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. **Microfluidic Systems for Materials Synthesis**
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. **Point-of-Care Diagnostics**
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. **Microscale DNA Amplification**
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. **Small volume Molecular Detection**
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. **Droplets and Segmented Flows**
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. **Single Cell Analysis**
    Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

**Lecture notes**
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

**Literature**
There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

**Fostered competencies**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-0209-00L</td>
<td>Renewable Energy Technologies</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Steinfeld, E. I. M. Casati</td>
</tr>
</tbody>
</table>

**Abstract**
Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

**Objective**
Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

**Lecture notes / notice**
Lecture Notes containing copies of the presented slides.

**Prerequisites**
Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

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</thead>
<tbody>
<tr>
<td>529-0659-00L</td>
<td>Electrochemistry: Fundamentals, Cells &amp; Applications</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>L. Gubler</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.

**Objective**
The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of materials science and engineering and how they are put to use in selected applications.
### Introduction: important quantities & units, terminology;

- Chapter I - Redox reactions, Faraday’s laws;
- Chapter II - Equilibrium electrochemistry: cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces: electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes: conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry: overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry: electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion: important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors: potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion: corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

**Lecture notes**
- Corrosion, Lecture notes, exercise & solutions (PDF files) via download website

**Literature**
  [German version available as well]

**Prerequisites / notice**
- Students should be familiar with the fundamentals of physical chemistry.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0745-01L</td>
<td>General and Environmental Toxicology</td>
<td>W</td>
<td>6 credits</td>
<td>3V</td>
<td>M. Arand, H. Nägeli</td>
</tr>
<tr>
<td>151-0109-00L</td>
<td>Turbulent Flows</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>P. Jenny</td>
</tr>
<tr>
<td>529-0611-01L</td>
<td>Molecular Aspects of Catalysts and Surfaces</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>J. A. van Bokhoven, D. Ferri</td>
</tr>
</tbody>
</table>

**Literature**
- Textbooks of pharmacology and toxicology (cf. list in course material)

### Systems and Process Engineering

#### Autumn Semester 2022

**Number**
- 529-0745-01L
- 151-0109-00L
- 529-0611-01L

**Abstract**
- Toxicokinetic and toxicodynamic aspects of xenobiotic interactions with cellular structures and mechanisms. Toxic responses at the level of organs (immune-, neuro-, reproductive and genotoxicity) and organisms. Introduction into developmental toxicology and ecotoxicology.
- Explanation of important interactions between xenobiocidal chemicals and cellular structures such as membranes, enzymes, and nucleic acids. Relevance of intake, distribution, excretion, and biochemical transformation processes. Relevance of mixtures. Explanation of important modes of toxic action such as immuno toxicity, neurotoxicity, reproduction toxicity, genotoxicity based on examples of certain xenobiotics and their effects on important organs.
- The fundamentals of physical chemistry; understanding of the impact of chemicals on biological systems; evaluation of the effects from different biomedical perspectives.
- Course material will be handed out as the lectures progress.

**Objective**
- To foster subject-specific competencies related to the theory and practice of physical chemistry in the context of toxicology.
- To provide students with the knowledge necessary to understand the effects of chemicals on biological systems.
- To equip students with the tools to evaluate the effects of chemicals on biological systems.

**Content**
- General and Environmental Toxicology
- Turbulent Flows
- Molecular Aspects of Catalysts and Surfaces

**Lecture notes**
- Lecture notes are available
- Lecture notes are available
- Lecture notes are available

**Literature**
- Textbooks of pharmacology and toxicology (cf. list in course material)
- Textbooks of pharmacology and toxicology (cf. list in course material)
- Textbooks of pharmacology and toxicology (cf. list in course material)

**Subject-specific Competencies**

**Concepts and Theories**

**Techniques and Technologies**

**Educational basis:** basic chemistry, biology and biochemistry

### Modeling and Simulations

- Methods which are covered embrace: Gas adsorption and surface area analysis, IR-Spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, X-ray absorption, solid state NMR, Electron Microscopy and others.
This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks

**Prerequisites / notice**

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

### Economics and Technology Management

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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0399-00L</td>
<td>Technology and Innovation Management</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Brusoni, A. Zeijen</td>
</tr>
</tbody>
</table>

**Abstract**

This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

**Objective**

This course intends to enable all students to:

- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

**Content**

This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

**Lecture notes**

Slides will be available on the Moodle page

**Literature**

Readings will be available on the Moodle page

**Prerequisites / notice**

The course content and methods are designed for students with some background in management and/or economics

**Fostered competencies**

Subject-specific Competencies: Concepts and Theories assessed
Techniques and Technologies assessed
Personal Competencies: Critical Thinking assessed

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>J.-E. Sturm</td>
</tr>
</tbody>
</table>

**Abstract**

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective**

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

**Content**

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

**Lecture notes**

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

**Literature**


This book can also be used for the course ‘363-0503-00L Principles of Macroeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
Abstract
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

Objective
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

Content
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
The book can also be used for the course ‘Principles of Microeconomics’ (Sturm)

For students taking only the course ‘Principles of Microeconomics’ there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where a larger topic is studied. Students are expected to actively develop chemical products along the course. Contributions will be made individually, or in small groups, where a larger topic is studied.

Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics, ...).

**Objective**

This course starts with analyzing existing chemical needs and unmet technical challenges. We then develop the skills to critically analyze a specific chemical idea for a product, to rapidly test feasibility or chance for success and to eventually realize its manufacturing. The chemical engineering basics are then used to assess performance of products or devices with non-traditional functions based on dynamic properties (e.g. responsive building materials; personal medical diagnostics on paper strips). The course teaches the interface between laboratory and market with a specific focus on evaluating the chemical value of a given process or compound, and the necessary steps to batch processes: scheduling, sizing, and inventories. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value generated.

Students are expected to actively develop chemical products along the course. Contributions will be made individually, or in small groups, where a larger topic is studied.

**Literature**


**Prerequisites / notice**

Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics, ...).
Overview of process simulation and flowsheeting:

**Title**
Rate-Controlled Separations in Fine Chemistry

**Lecturers**
G. Guillén Gosálbez, V. Becattini

**ECTS**
3

**Hours**
6

**Prerequisites / notice**
A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

**Content**
- Definition and fundamentals
- Fields of application
- Case studies
- Process simulation:
  - Modeling strategies of process systems
  - Mass and energy balances and degrees of freedom of process units and process systems
- Process flowsheeting:
  - Flowsheet partitioning and tearing
  - Solution methods for process flowsheeting
  - Simultaneous methods
  - Sequential methods
- Process optimization and analysis:
  - Classification of optimization problems
  - Linear programming, LP
  - Non-linear programming, NLP
  - Mixed-integer linear programming, MILP
  - Mixed-integer nonlinear programming, MINLP
- Commercial software for simulation (Aspen Plus):
  - Thermodynamic property methods
  - Reaction and reactors
  - Separation / columns
  - Convergence, optimisation & debugging

**Literature**
- Smith, R. Chemical process design and integration, Wiley (2005).

**Prerequisite** Basic knowledge on unit operations, mainly reaction engineering and distillation. It is recommended that the student takes the module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

**Abstract**
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheeting and optimization problems.

**Objective**
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

**Number**
151-0927-00L

**Title**
Rate-Controlled Separations in Fine Chemistry

**Type**
W

**ECTS**
6

**Hours**
3V+1U

**Lecturers**
M. Mazzotti, V. Becattini

**Abstract**
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.

**Objective**
The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.
Heterogeneous catalysis, an enabling foundation of the chemical industry, spearheads innovation toward key sustainability targets in clean energy, carbon neutrality, and zero waste. The Catalysis Engineering course provides students with concepts bridging from the molecular-level design of catalytic materials to their technical application. Studies both in lectures and through a semester project, you will see aspects of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalyst design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

A supervised semester project conducted in small groups provides a taster of catalysis research on a timely topic. Students will learn basic skills including critical literature analysis, problem definition and solving, methods of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalyst design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

The aspects described above will be demonstrated through industrially-relevant examples such as:

- Natural gas valorization
- CO₂ conversion to energy vectors
- Plastics upcycling
- Concept for a glycerol biorefinery
- Halogen chemistry on catalytic surfaces
- Ensemble design for selective hydrogenations
- Single-atom catalysis
- Hierarchical zeolite catalysts

A supervised semester project conducted in small groups provides a taster of catalysis research on a timely topic. Students will learn basic skills including critical literature analysis, problem definition and solving, methods of catalyst synthesis and characterization, kinetics, mass and heat transport, deactivation and process design, sustainability metrics, and the potential of digital tools to guide catalyst design. Since this area is rapidly advancing and no textbooks are available, the lectures follow slides and journal articles.

The course material is based on slides and journal articles.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

see Science in Perspective: Language Courses ETH/UZH

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0051-AAL</td>
<td>Analytical Chemistry I</td>
<td>E-</td>
<td>3 credits</td>
<td>6R</td>
<td>D. Günther, R. Zenobi</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

The underlying lecture (529-0051-00L) is offered in autumn semester but only in German.

Introduction into the most important spectroscopical methods and their applications to gain structural information.

Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications.
Content Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.
UV/VIS spectroscopy: Basics, interpretation of electron spectra. Circular dichroism (CD) und optical rotation dispersion (ORD).

Lecture notes Script will be provided for the production price

- M. Hesse, H. Meier, B. Zeich, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

Prerequisites / notice Exercices are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

Chemical and Bioengineering Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>W+</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
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<table>
<thead>
<tr>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
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</thead>
<tbody>
<tr>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
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<th>U</th>
<th>S</th>
<th>K</th>
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<tbody>
<tr>
<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<table>
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<th>P</th>
<th>A</th>
<th>D</th>
<th>R</th>
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<tbody>
<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Chemical Engineering Bachelor

1. Semester

Compulsory Subjects First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0011-02L</td>
<td>General Chemistry (inorganic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective</td>
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</tr>
<tr>
<td>Content</td>
<td>Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium concentrations, acidity functions, Lewis acids, acids in non-aqueous solvents, redox reactions and equilibria, Galvanic cells, electrode potentials, Nernst equation, coordination chemistry, stepwise formation of metal complexes, solubility</td>
<td></td>
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<tr>
<td>Lecture notes</td>
<td>Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.</td>
<td></td>
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<tr>
<td>529-0011-03L</td>
<td>General Chemistry (Organic Chemistry) I</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Chen</td>
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<tr>
<td>Abstract</td>
<td>Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.</td>
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<tr>
<td>Objective</td>
<td>Introduction to the history of organic chemistry, introduction to nomenclature, learning of classical structures and stereochemistry: isomerism, Fischer projections, CIP rules, point groups, molecular symmetry and chirality, topicity, chemical bonding: Lewis bonding model and resonance theory in organic chemistry, description of linear and cyclic conjugated molecules, aromaticity, Huckel rules, organic thermochemistry, learning of organic chemistry reactions, intramolecular interactions.</td>
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<tr>
<td>Lecture notes</td>
<td>Underlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt</td>
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<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<tr>
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<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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<td>Negotiation</td>
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<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-management</td>
<td>assessed</td>
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</table>

529-0011-01L

General Chemistry (Physical Chemistry) I

Abstract

The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.

Objective

After the lecture, students will be able to,
- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- analyze and calculate absorption and emission spectra of single-electron atoms,
- to set up the Schrödinger equation for a molecular multi-particle system,
- independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems,
- model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model,
- explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom,
- explain the structure of the periodic table of elements with the help of the orbital concept,
- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and
- establish term symbols for atomic ground states.

Content

Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

Lecture notes

See homepage of the lecture.

Literature

See homepage of the lecture.

Prerequisites / notice

Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentialrechnung.
Physics I

Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.

Objective
The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

Content
Mechanics (motion, Newton’s laws, work and energy, conservation of momentum, rotation, gravitation, fluids)
Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

Lecture notes
The lecture follows the book “Physics” by Paul A. Tipler.

Literature
Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company

Mathematical Foundations I: Analysis A

Abstract
Introduction to calculus in one dimension. Building simple models and analysing them mathematically. Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Objective
Introduction to calculus in one dimension. Building simple models and analysing them mathematically.

Content
Functions of one variable: the notion of a function, of the derivative, the idea of a differential equation, complex numbers, Taylor polynomials and Taylor series. The integral of a function of one variable.

Literature
G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und Übungsbuch, Pearson-Verlag
R. Sperb/M. Akveld: Analysis I (vdf)
L. Papula: Mathematik für Ingenieure und Naturwissenschaftler (3 Bände), Vieweg

Introduction to Computer Science

Abstract
Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

Objective
Acquire a starting package concerning the computational aspects of natural sciences; discuss fundamentals of computer architecture, languages, algorithms and programming with an eye to their application in the area of chemistry, biology and material science.

Content
Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation; Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

Lecture notes
Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.

Literature
See: www.csms.ethz.ch/education/Infol

Prerequisites / notice
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/Infol

Laboratory Courses

Number Title Type ECTS Hours Lecturers
529-0011-04L Practical Course General Chemistry 2 8 credits 12P H. V. Schönberg, E. C. Meister

Information about the practical course will be given on the first day.

Qualitative analysis (determination of cations and anions), acid-base-equilibria (pH-values, titrations, buffer), precipitation equilibria (gravimetry, potentiometry, conductivity), redoxreactions (syntheses, redox-titrations, galvanic elements), metal complexes (syntheses, complexometric titration), Analysis of measured data, vapour pressure, conductivity, calorimetry, solubility.
The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their state of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes
http://www.gruetzmacher.ethz.ch/education/labcourses

Literature
Moodle Lernplattform

Prerequisites / notice
Compulsory: online enrolment latest one week after start of the semester

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

3. Semester

Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0121-00L</td>
<td>Inorganic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. Grützmacher, P. Steingraber</td>
</tr>
</tbody>
</table>

Objective
Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKₐ-values, titrations, buffer systems, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation state and redox behaviour (syntheses), redox-titrations, galvanic elements, metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration) analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimetry, solubility).

Content
The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their state of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes
http://www.gruetzmacher.ethz.ch/education/labcourses

Literature
Moodle Lernplattform

Prerequisites / notice
Compulsory: online enrolment latest one week after start of the semester

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tbody>
<tr>
<td>529-0221-00L</td>
<td>Organic Chemistry I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. Wennemers</td>
</tr>
</tbody>
</table>

Abstract
This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

Objective
This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

Content
This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.

Lecture notes
The lecture slides, problem sets, and additional documents are provided online. Link: https://wennemers.ethz.ch/education.html

Literature

Examination Block I

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>R. Signorelli</td>
</tr>
</tbody>
</table>

Abstract
Objective
Introduction to Chemical Reaction Kinetics

Content

Lecture notes
Will be provided

Literature

Prerequisites /
Voraussetzungen:
- Mathematik I und II
- Allgemeine Chemie I und II
- Physiskalische Chemie I

529-0051-00L Analytical Chemistry I O 3 credits 3G D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi

Abstract
Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

Lecture notes
Script will be for the production price

Literature
- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

Prerequisites /
Excercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

401-0373-00L Mathematics III: Partial Differential Equations O 4 credits 2V+1U L. Kobel-Keller

Abstract

Objective
Classical tools to solve the most common linear partial differential equations.

Content
1) Examples of partial differential equations
- Classification of PDEs
- Superposition principle

2) One-dimensional wave equation
- D'Alembert's formula
- Duhamel's principle

3) Fourier series
- Representation of piecewise continuous functions via Fourier series
- Examples and applications

4) Separation of variables
- Solution of wave and heat equation
- Homogeneous and inhomogeneous boundary conditions
- Dirichlet and Neumann boundary conditions

5) Laplace equation
- Solution of Laplace's equation on the rectangle, disk and annulus
- Poisson formula
- Mean value theorem and maximum principle

6) Fourier transform
- Derivation and definition
- Inverse Fourier transformation and inversion formula
- Interpretation and properties of the Fourier transform
- Solution of the heat equation

7) Laplace transform (if time allows)
- Definition, motivation and properties
- Inverse Laplace transform of rational functions
- Application to ordinary differential equations

Lecture notes
See the course web site (linked under Lernmaterialien)


4) E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1, 2, 11, 12, 6)

Prerequisites / notice
1) Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant
2) Multiple integrals: Riemann integrals in two or three variables, change of variables
2) Sequences and series of numbers and of functions
3) Basic knowledge of ordinary differential equations

Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>529-0129-00L</td>
<td>Inorganic and Organic Chemistry II</td>
<td>O</td>
<td>11 credits</td>
<td>16P</td>
<td>V. Mougel</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the experimental methods of Inorganic Chemistry

Objective
The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a main topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques.

Content
Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra. Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.

Lecture notes
A manual is distributed in the teaching laboratory.

Prerequisites / notice
- Passed Basisprüfung
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)
- Continuous Attendance of Course Inorg. Chemistry 1 (3. Sem., 529-0121) and Analytical Chemistry 1 (3. Sem., 529-0051)

If necessary, access priority will be settled according to the results of the first-year examinations.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td></td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td></td>
</tr>
</tbody>
</table>

Method-specific Competencies

| Analytical Competencies                       | Assessed |
| Decision-making                               |          |
| Media and Digital Technologies                |          |
| Problem-solving                               |          |
| Project Management                            |          |

Social Competencies

| Communication                                 | Assessed |
| Cooperation and Teamwork                      |          |
| Customer Orientation                          | not assessed |
| Leadership and Responsibility                 |          |
| Self-presentation and Social Influence        | not assessed |
| Sensitivity to Diversity                      | not assessed |
| Negotiation                                   | not assessed |

Personal Competencies

| Adaptability and Flexibility                  | Assessed |
| Creative Thinking                             |          |
| Critical Thinking                             |          |
| Integrity and Work Ethics                     |          |
| Self-awareness and Self-reflection            |          |
| Self-direction and Self-management            |          |

5. Semester

Compulsory Subjects

Examination Block II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0557-00L</td>
<td>Chemical Engineering Thermodynamics</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>A. de Mello, S. Stavrakis</td>
</tr>
</tbody>
</table>

Abstract
This course introduces the basic principles and concepts of chemical engineering thermodynamics. Whilst providing insights into the meaning and properties of fundamental thermodynamic quantities, the course also has a primary focus on the application of thermodynamic concepts to real chemical engineering problems.
The first part of the course introduces the basic concepts and language of chemical engineering thermodynamics. This is followed by an analysis of energy and energy transfer, with a specific focus on the concept of work and the first law of thermodynamics. Next, the notion of a pure substance is introduced, with a discussion of the physics of phase-changes being presented. The description of pure substances is further developed through an analysis of the PVT behavior of fluids, equation of states, ideal and non-ideal gas behaviour and compressibility factors.

The second part of the course begins with a discussion of the use of the energy balance relation in closed systems that involve pure substances and then develops relations for the internal energy and enthalpy of ideal gases. Next, the second law of thermodynamics is introduced, with a discussion of why processes occur in certain directions and why energy has quality as well as quantity. Applications to cyclic devices such as thermal energy reservoirs, heat engines and refrigerators are provided. Entropy changes that take place during processes for pure substances, incompressible substances and ideal gases are described.

The third part of the course establishes thermodynamic formulations for the calculation of enthalpy, internal energy and entropy as function of pressure and temperature, Gibbs energy, fugacity and chemical potential. Two-phase systems are introduced as well as the use of equations of state to construct the complete phase diagrams of pure fluid.

The final part of the course focuses on the properties of mixtures and the phase behavior of multicomponent systems. The fundamental equations of phase equilibria in terms of the chemical potential and fugacity are also discussed. The concept of an ideal solution is introduced and developed. This is followed by an assessment of non-ideal behavior and the use of activity coefficients for describing phase diagrams. Particular focus is given to phase equilibria. Finally, concepts relating to chemical equilibria are introduced with the general concepts developed being applied to reacting species. Examples here include the calculation of the Gibbs free energy and the equilibrium constant of a reaction.

Resources for the acquisition of material properties and data:

1. NIST Chemistry WebBook (https://webbook.nist.gov/chemistry/)
2. CRC Handbook of Chemistry & Physics, 99th Edition (http://hbcponline.com/)

Although there is not set text for the course, the following three texts will be used in part and are excellent introductions to Chemical Engineering thermodynamics:


Prerequisites / notice

A basic knowledge of chemical thermodynamics is required.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Personal Competencies

Creative Thinking

Critical Thinking

Mass Transfer 151-0917-00L

4 credits

2 credits

S. E. Pratsinis, V. Mavrantzas, C.-S. Lai

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Literature


Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

Heat Transport and Fluid Dynamics 529-0636-00L

4 credits

4G

A. A. Kubik

This course teaches the basis and the methods for the description and for the quantitative treatment of heat transfer and fluid flow with emphasis on physico-chemical processes

At the end of this course students should be familiar with the basics of heat transfer and fluid dynamics, and have acquired the ability to describe these phenomena in practical processes and to perform corresponding calculations

Mechanisms of heat and momentum transfer; analogy between mass, heat and momentum transfer; dimensional analysis; kinematics and continuum mechanics; steady and non-steady; laminar and turbulent flow; inviscid flows; Bernoulli equation; Navier-Stokes equations; boundary layer theory; steady and non-steady heat conduction; convective heat transfer; heat transfer correlations; radiative heat transfer

Lecture notes

Lecture notes will be handed out

Examination Block III

Number Title Type ECTS Hours Lecturers

Autumn Semester 2022
### 529-0632-00L Homogeneous Reaction Engineering

**Abstract**


**Objective**

Provide to the students a complete methodology for the analysis and design of homogeneous reactors

**Content**


**Lecture notes**

Scripts are available on line on the page of the Arosio group.

**Literature**


### 752-4001-00L Microbiology

**Abstract**

Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phenylogy and Taxonomy, Prokaryotic Diversity. Human-Microbe Interactions, Biotechnology.

**Objective**

Teaching of basic knowledge in microbiology.

**Content**


**Lecture notes**

Wird von den jeweiligen Dozenten ausgegeben.

**Literature**

Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

### 401-0675-00L Statistical and Numerical Methods for Chemical Engineers

**Abstract**

This course covers common numerical algorithms and statistical methods used by chemical engineers to solve typical problems arising in industrial and research practice.

**Objective**

This course covers common numerical algorithms and statistical methods used by chemical engineers to solve typical problems arising in industrial and research practice. The focus is on application of these algorithms to real world problems, while the underlying mathematical principles are also explained. The MATLAB environment is adopted to integrate computation, visualization and programming.

**Content**

Topics covered:

- Part I: Numerical Methods:
  - Interpolation & Numerical Calculus
  - Non-linear Equations
  - Ordinary Differential Equations
  - Partial Differential Equations
  - Linear and Non-linear Least Squares

- Part II: Statistical Methods:
  - Data analysis and regression methods
  - Statistical experimental design
  - Multivariate analysis

**Lecture notes**

For the numerics part, see http://www.sam.math.ethz.ch/~karoger/numci/2022/

For the statistics part, see http://stat.ethz.ch/lectures/as22/statistical-numerical-methods.php

**Literature**

Recommended reading:

2) K. J. Beers, Numerical Methods for Chemical Engineering ; Applications in MATLAB, Cambridge : Cambridge University Press, 2006
4) W. A. Stahel, Statistische Datenanalyse, Vieweg, 4th edition 2002

### 351-0778-00L Discovering Management

**Abstract**

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:

1) broaden understanding of management principles and frameworks
2) advance insights into the sources of corporate and entrepreneurial success
3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

**Content**

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed

Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

Social Competencies
- Communication assessed
- Self-presentation and Social Influence assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

Examination Block IV
Offered in the Spring Semester.

Examination Block V
Offered in the Spring Semester.

Laboratory Courses and Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
The focus of part I of the case study course lies on the literature-based comparison of chemical process alternatives. Based on this compilation and selected quantitative as well as qualitative measures, a process assessment and comparison is conducted. A basic flowsheet is then generated, and mass and energy balances are performed to carry out a preliminary economic and environmental assessment.

Objective
- to obtain knowledge about different databases and sources of information
- application of the knowledge obtained in lectures to a real problem
- problem-oriented problem solving (application of different methods to the same subject)
- team work
- report writing and presentation techniques

Content
The focus of part I of the case study course lies on the literature-based comparison of chemical process alternatives. For this purpose, relevant substance data (i.e. physico-chemical, toxicological, safety, and environmental data), as well as information about synthesis routes and technical implementations (i.e. on reaction kinetics; possible separation operations; economic, safety, and environmental aspects), are collected from the literature. Based on this compilation and selected quantitative as well as qualitative measures, a process assessment and comparison is conducted and the most promising process alternative is chosen for further evaluation. For this alternative, a basic flowsheet and mass and energy balances are generated.

529-0639-01L Chemical Engineering Laboratory | O | 6 credits | 8P | N. Kobert, R. Grass

Abstract
Introduction to various tools of chemical engineering techniques with reference to the lectures. In groups of two, students will conduct experiments in the following areas: thermodynamics and phase equilibria including electrochemistry, transport phenomena, kinetics and selectivity of complex reactions, characterisation of ideal and real reactors.

Objective
Introduction to various tools of chemical engineering techniques with reference to the running lectures.

Content
In groups of two, students will conduct selected experiments in the following areas: thermodynamics and phase equilibria including electrochemistry, transport phenomena, kinetics and selectivity of complex reactions, characterisation of ideal and real reactors.

Prerequisites / notice
Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html

Science in Perspective

Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

Language Courses

see Science in Perspective: Language Courses ETH/UZH

Chemical Engineering Bachelor - Key for Type

| E- | Recommended, not eligible for credits | O | Compulsory |
| Z | Courses outside the curriculum | W+ | Eligible for credits and recommended |
| Dr | Suitable for doctorate | W | Eligible for credits |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium | |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Comparative and International Studies Master

#### Core Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>857-0001-00L</td>
<td>Methods I: Research Design, Qualitative Methods, and Data Collection</td>
<td>O</td>
<td>6</td>
<td>2U+2S</td>
<td>M. Jacob, F. Schimmelfennig, C. Freudlsperger, M. Nasr</td>
</tr>
</tbody>
</table>

#### Research Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>857-0010-00L</td>
<td>Topics in Public Policy: Governing the Energy Transition</td>
<td>O</td>
<td>6</td>
<td>2S</td>
<td>S. Sewerin, N. Schmid</td>
</tr>
</tbody>
</table>
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the role of public policy and policy change in governing complex socio-technical transitions, considering the role of political actors, institutions and policy feedback.

The course has a highly interactive (seminar-like) character. Students are expected to actively engage in the weekly discussions and give a presentation (15-20 minutes) on one of the weekly topics during that particular session. In addition to the weekly lectures, students will write a research paper of approximately 6000 words, guided by and in collaboration with the lecturers.

Active participation in the seminar (15%) and the presentation (15%) will form one part of the final grade, with the research paper forming the rest (70%).

Upon completion, course participants will have first-hand experience with collaborative research including project management, spanning the entire project cycle from ideation, study design and pre-analysis planning, field phase and data collection, statistical analysis and paper writing.

This seminar complements the MACIS core seminar in Political Economy. It covers topics such as international trade, environmental policy, international finance and foreign direct investment, and welfare state policy. Students will, based on reading assignments and discussions in class, develop a research question, present a research design, and write a paper.

This seminar is restricted to students enrolled in the MACIS program.

### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>860-0023-00L</td>
<td>International Environmental Politics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>T. Bernauer</td>
</tr>
</tbody>
</table>

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

857-0027-00L International Organizations (Field Trip) - 2 credits

Objective
- Become familiar with the work and challenges of international organizations based in Geneva.

Prerequisites / notice
- Teams of 2-3 students prepare a 2-3 page background reading for the group on a specific international organization and lead the discussion with representatives of that organization during the visit.

851-0609-06L Governing the Energy Transition - 2 credits

Objective
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions
- To gain knowledge on the role of policy and politics in energy transitions

Content
- Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary.

This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

865-0064-00L Decolonizing Aid - 2 credits

Objective
- Decolonialism key terms and concepts
- Conceptualizations of aid as development cooperation
- Cultural (self- )awareness, diversity
- The role of culture in aid / development cooperation
- Implications of decolonialism for aid policy making and practice

Content
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

865-0070-00L The Private Sector and Development Organizations - 1 credit

Objective
This course is designed to increase awareness of how cultural perceptions and power structures have influenced society and our understanding of and practice in aid. It promotes alternatives to aid as linear and progressive Eurocentric narratives. The course draws on different theoretical perspectives and scrutinizes practical examples of aid interventions and similar initiatives.

Content
- Decolonialism key terms and concepts
- Conceptualizations of aid as development cooperation
- Cultural (self- )awareness, diversity
- The role of culture in aid / development cooperation
- Implications of decolonialism for aid policy making and practice

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Reading materials and slides will be available via Moodle.

Prerequisites / notice
This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.
Only for MAS/CAS in Development and Cooperation students, as well as specialists with at least 24 months of practical experience in international cooperation. Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted "sur Dossier".

Registration only through the NADEL administration office.

Abstract
The following topics will be discussed: The political economy of the Corporate Social Responsibility discourse, voluntary governance regimes and development: theory of change and effectiveness of soft law approaches, PPPs: introducing concepts and taking stock of experience, analysis of private sector strategies from selected governance actors, engaging with the private sector. Doctoral students dealing with empirical research in the area of development and cooperation (EZA) may be admitted "sur Dossier".

Registration only through the NADEL administration office.

Objective
This course seeks to increase the participants' understanding of the multifaceted and dialectic relationships between civil society, governments and private sector. It equips participants with knowledge and tools required for a strategic interaction between private sector organizations and development agencies. The course enables participants to contribute effectively to policy debates on the role of private sector actors and development.

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL.

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>857-0019-00L</td>
<td>Master's Thesis Colloquium</td>
<td>O</td>
<td>4 credits</td>
<td>3K</td>
<td>J. Spirig</td>
</tr>
</tbody>
</table>

Permission to begin master thesis is required to take part in Colloquium.

Abstract
In this colloquium, students enrolled in the MACIS program first present and discuss research design and methods issues concerning their prospective MA theses. Towards the end of the semester they present preliminary findings from their MA thesis work.

Objective
It is the goal of the colloquium to help students with the initial steps of writing their master theses. During the colloquium, they will develop a relevant research question and hypotheses and select appropriate methods and data.

| 857-0021-00L | Master's Thesis | O    | 26 credits | 56D | Professors |

Only students who fulfill the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract
The Master Thesis is an independent piece of research on an issue in comparative and international politics. It combines theory, methods, and empirical work.

Objective
The Thesis should demonstrate the students' ability to conduct independent research on the basis of the theoretical and methodological knowledge acquired during the MA program.

Comparative and International Studies Master - Key for Type

| O          | Compulsory                                          | E-   | Recommended, not eligible for credits |
| W+         | Eligible for credits and recommended                | Z    | Courses outside the curriculum       |
| W          | Eligible for credits                                | Dr   | Suitable for doctorate               |

Key for Hours

| V          | lecture                                             | P    | practical/laboratory course          |
| G          | lecture with exercise                               | A    | independent project                  |
| U          | exercise                                            | D    | diploma thesis                       |
| S          | seminar                                             | R    | revision course / private study      |
| K          | colloquium                                          |      |                                        |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Evolutionary Dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

Lectures will be available on moodle.

Objective

The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Content

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

Computational Biology is the study of the design, development, and application of computational methods and tools to carry out experiments on and solve problems in biology. The main concept introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- * epidemiology
- * pathogen evolution
- * macroevolution of species

Core Courses: Evolutionary Dynamics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0009-00L</td>
<td>Evolutionary Dynamics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U+2A</td>
<td>N. Beerenwinkel</td>
</tr>
</tbody>
</table>

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Abstract

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Lecture notes

Lecture slides will be available on moodle.

Literature


Prerequisites / notice

Prerequisites: Basic mathematics (linear algebra, calculus, probability)

Fostered competencies

Subject-specific Competencies

- Concepts and Theories

Method-specific Competencies

- Analytical Competencies

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phyloдинamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Core Courses: Computational Biology

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0017-00L</td>
<td>Computational Biology</td>
<td>W</td>
<td>6 credits</td>
<td>3G+2A</td>
<td>T. Vaughan, C. Magnus, T. Stadler</td>
</tr>
</tbody>
</table>

Computational Biology is the study of the design, development, and application of computational methods and tools to carry out experiments on and solve problems in biology. The main concept introduced are:

Abstract

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- * epidemiology
- * pathogen evolution
- * macroevolution of species

Content

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phyloдинamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes

Lecture slides will be available on moodle.

Literature

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

Core Courses: Evolutionary Genetics

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>262-6100-00L</td>
<td>Evolutionary Genetics</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>external organisers</td>
</tr>
</tbody>
</table>

Evolutionary genetics covers three important areas of modern evolutionary genetics: bioinformatics, molecular evolution and population genetics. Treating these three areas together in a single course provides an integrated education in evolutionary genetics. A solid understanding of these areas is also central to other fields such as conservation biology or behavioural and evolutionary ecology.

Abstract

Evolutionary genetics covers three important areas of modern evolutionary genetics: bioinformatics, molecular evolution and population genetics. Treating these three areas together in a single course provides an integrated education in evolutionary genetics. A solid understanding of these areas is also central to other fields such as conservation biology or behavioural and evolutionary ecology.

Objective

Students can understand the main algorithmic design principles for problems like sequence alignment, motif finding and phylogenetic inference. Further, students get an overview of modern machine learning methods and their applications to bio-medical problems.

Core Courses: Bioinformatics

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>262-6110-00L</td>
<td>Bioinformatics Algorithms</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>external organisers</td>
</tr>
</tbody>
</table>

In this lecture, an introduction into main bioinformatics algorithms is provided. We will discuss both "classical" topics such as Hidden Markov Models, Markov chains, phylogenetic trees and "modern" approaches based on sophisticated (deep) learning models.

Objective

Students can understand the main algorithmic design principles for problems like sequence alignment, motif finding and phylogenetic inference. Further, students get an overview of modern machine learning methods and their applications to bio-medical problems.
A range of topics will be covered, including basic molecular biology, genomics technologies and in particular, a wide range of statistical and computational methods that have been used in the analysis of DNA microarray and high throughput sequencing experiments.

Objective
- Understand the fundamental "scientific process" in the field of Statistical Bioinformatics
- Be equipped with the skills/tools to preprocess genomic data (Unix, Bioconductor, mapping, etc.) and ensure reproducible research (Sweave)
- Have a general knowledge of the types of data and biological applications encountered with microarray and sequencing data
- Have the general knowledge of the range of statistical methods that get used with microarray and sequencing data
- Gain the ability to apply statistical methods/knowledge/software to a collaborative biological project
- Gain the ability to critically assess the statistical bioinformatics literature
- Write a coherent summary of a bioinformatics problem and its solution in statistical terms

Content
Lectures will include: microarray preprocessing; normalization; exploratory data analysis techniques such as clustering,PCA and multidimensional scaling; Controlling error rates of statistical tests (FPR versus FDR versus FWER); limma (linear models for microarray analysis); mapping algorithms (for RNA/ChIP-seq); RNA-seq quantification; statistical analyses for differential count data; isoform switching; epigenomics data including DNA methylation; gene set analyses; classification

Lecture notes
Lecture notes, published manuscripts

Prerequisites / notice
Prerequisites: Basic knowledge of the programming language R, sufficient knowledge in statistics

Former course title: Statistical Methods for the Analysis of Microarray and Short-Read Sequencing Data

Biophysics

Number Title Number Type ECTS Hours Lecturers
262-6106-01L Current Topics in Biophysics W 6 credits 3G external organisers

Abstract
This course reviews how ideas and concepts from physics have helped understanding biological systems by discussing landmark papers in the field.

636-0104-00L Biophysical Methods W 4 credits 3G D. J. Müller

Abstract
Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective
Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content
The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:
- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
- Super resolution optical microscopy: STED, PALM, STORM, other variations
- Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
- X-ray, electron and neutron diffraction
- MRI imaging
- Scanning tunnelling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
- Surface plasmon resonance-based biosensors
- Molecular pore-based sensors and sequencing devices
- Mechanical molecular and cellular assembly devices
- Optical and magnetic tweezers
- CD spectroscopy
- Optogenetics
- Molecular dynamics simulations

Lecture notes
Hand out will be given to students at lecture.

Literature
Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press
Biophysics (5th edition), Berg, Tymoczko, Stryer; ISBN 0-7167-4684-0, Freeman

Prerequisites / notice
The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with under the guidance of the teacher.

529-0004-01L Classical Simulation of (Bio)Molecular Systems W 6 credits 4G P. H. Hünenberger, J. Dolenc, S. Riniker

Abstract
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective
Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).
Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze and model complex biological networks. The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

The course provides an introduction to key concepts in developmental biology. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

### Biosystems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
<tr>
<td>636-0706-00L</td>
<td>Spatio-Temporal Modelling in Biology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Iber</td>
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<tr>
<td>636-0117-00L</td>
<td>Mathematical Modelling for Bioengineering and Systems Biology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Iber</td>
</tr>
</tbody>
</table>

### Literature

- See: www.csms.ethz.ch/education/CSBMS
- For more information about the lecture: www.csms.ethz.ch/education/CSBMS

### Prerequisites / notice

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

### Content

- **Biology**: An introduction to key concepts in developmental biology.

### References


### Prerequisites / notice

The course provides an introduction to key concepts in developmental biology. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

### Notes

- All lecture material will be made available online via Moodle.
- The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:
  - Murray, Mathematical Biology, Springer
  - Forcenas and Newman, Biological Physics of the Developing Embryo, CUP
  - Keener and Sneyd, Mathematical Physiology, Springer
  - Fall et al, Computational Cell Biology, Springer
  - Szallasi et al, System Modeling in Cellular Biology, MIT Press
  - Wolkenhauer, Systems Biology
  - Kreyzig, Engineering Mathematics, Wiley

### Prerequisites / notice

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>636-0018-00L</td>
<td>Data Mining I</td>
<td>W</td>
<td>6</td>
<td>3G+2A</td>
<td>K. M. Borgwardt</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Data Mining, the search for statistical dependencies in large databases, is of utmost important in modern society, in particular in biological and medical research. This course provides an introduction to the key problems, concepts, and algorithms in data mining, and the applications of data mining in computational biology.</td>
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<td><strong>Objective</strong></td>
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<td>The goal of this course is that the participants gain an understanding of data mining problems and algorithms to solve these problems, in particular in biological and medical applications.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>The goal of the field of data mining is to find patterns and statistical dependencies in large databases, to gain an understanding of the underlying system from which the data were obtained. In computational biology, data mining contributes to the analysis of vast experimental data generated by high-throughput technologies, and thereby enables the generation of new hypotheses.</td>
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<td>In this course, we will present the algorithmic foundations of data mining and its applications in computational biology. The course will feature an introduction to popular data mining problems and algorithms, reaching from classification via clustering to feature selection. This course is intended for both students who are interested in applying data mining algorithms and students who would like to gain an understanding of the key algorithmic concepts in data mining.</td>
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<td>Tentative list of topics:</td>
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<td></td>
<td>1. Distance functions</td>
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<td>2. Classification</td>
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<td>3. Clustering</td>
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<td>4. Feature Selection</td>
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<td><strong>Lecture notes</strong></td>
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<td>Course material will be provided in form of slides.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td>Will be provided during the course.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Basic understanding of mathematics, as taught in basic mathematics courses at the Bachelor’s level.</td>
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<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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<td>Topics covered in the lecture include:</td>
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<td>Fundamentals:</td>
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<td>What is data?</td>
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<td>Bayesian Learning</td>
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<td></td>
<td>Computational learning theory</td>
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<td>Supervised learning:</td>
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<td>Ensembles: Bagging and Boosting</td>
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<td>Max Margin methods</td>
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<td></td>
<td>Neural networks</td>
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<td>Unsupervised learning:</td>
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<tr>
<td></td>
<td>Dimensionality reduction techniques</td>
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<td></td>
<td>Clustering</td>
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<td></td>
<td>Mixture Models</td>
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<td>Non-parametric density estimation</td>
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<td>Learning Dynamical Systems</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td>The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least &quot;Introduction to Machine Learning&quot; or an equivalent course offered by another institution.</td>
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<td></td>
<td>PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.</td>
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<tr>
<td>636-0101-00L</td>
<td>Systems Genomics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Treutlein, C. Beisel, Z. He</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
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<td></td>
<td>This course is an introduction to the wide field of Genomics. It addresses how fundamental questions in biological systems are studied using methods in genomics and how the resulting data is analysed to make quantitative interpretations of biological phenomena.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>The goal of this course is to get detailed insights in how state-of-the-art DNA sequencing technologies can be applied for a qualitative and quantitative description of molecular and cellular processes and function. Students will learn how to analyse RNA-seq / transcriptomics data and make biological interpretations in a quantitative manner.</td>
</tr>
</tbody>
</table>
Content

This course will be a mix of lecture sessions, hands-on computational data analysis using public datasets and seminars discussing own results in the context of the published studies. In the lectures we will introduce current Next-Generation Sequencing technologies and their application to address basically all facets of modern biology and biomedical research. We will cover the major sample processing methods used for investigating functional genomic aspects like transcriptome and chromatin profiling, review recent advances in (cancer) genome sequencing and give an overview of public big data sequencing projects (ENCODEx, GTEx, TOGA, ...).

For the computational data analysis we will focus on differential gene expression profiling (RNA-seq) experiments that have been selected from fascinating published biological studies. Data analysis based on R will follow a detailed tutorial describing all required steps of sequence read processing and will be conducted in small groups to enable every student hands-on experience.

Lecture notes

The PowerPoint presentations of the lectures as well as other course material relevant for an active participation will be made available online.

Seminar

Compulsory seminar.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

Computational biology and bioinformatics aim at an understanding of living systems through computation. The seminar combines student presentations and current research project presentations to review the rapidly developing field from a computer science perspective.

Areas: DNA sequence analysis, proteomics, optimization and bio-inspired computing, and systems modeling, simulation and analysis.

Objective

Studying and presenting fundamental papers of Computational Biology and Bioinformatics. Learning how to make a scientific presentation and how classical methods are used or further developed in current research.

Content

Computational biology and bioinformatics aim at advancing the understanding of living systems through computation. The complexity of these systems, however, provides challenges for software and algorithms, and often requires entirely novel approaches in computer science. The aim of the seminar is to give an overview of this rapidly developing field from a computer science perspective. In particular, it will focus on the areas of (i) DNA sequence analysis, sequence comparison and reconstruction of phylogenetic trees, (ii) protein identification from experimental data, (iii) optimization and bio-inspired computing, and (iv) systems analysis of complex biological networks.

The seminar combines the discussion of selected research papers with a major impact in their domain by the students with the presentation of current active research projects / open challenges in computational biology and bioinformatics by the lecturers. Each week, the seminar will focus on a different topic related to ongoing research projects at ETHZ, University of Basel and University of Zurich, thus giving the students the opportunity of obtaining knowledge about the basic research approaches and problems as well as of gaining insight into (and getting excited about) the latest developments in the field.

Literature

Original papers to be provided by the students will be presented in the first week of the seminar.

Advanced Courses

A total of 30 ECTS needs to be acquired in the Advanced Courses category. Thereof at least 16 ECTS in the Theory category.

Note that some of the lectures are being recorded: https://video.ethz.ch/lectures.html

Theory

At least 16 ECTS need to be acquired in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0663-00L</td>
<td>Numerical Methods for Computer Science</td>
<td>W</td>
<td>7 credits</td>
<td>2V+2U+2P</td>
<td>R. Hiptmair</td>
</tr>
</tbody>
</table>

Abstract

The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods.

The exercises involve actual implementation of numerical methods in C++.

* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently
First two weeks: A gentle introduction to C++

1. Computing with Matrices and Vectors
   1.1 Fundamentals
   1.2 Software and Libraries
   1.4 Computational Effort
   1.5 Machine Arithmetic and Consequences

2. Direct Methods for (Square) Linear Systems of Equations
   2.1 Introduction: Linear Systems of Equations
   2.3 Gaussian Elimination
   2.6 Exploiting Structure when Solving Linear Systems
   2.7 Sparse Linear Systems

3. Direct Methods for Linear Least Squares Problems
   3.1 Least Squares Solution Concepts
   3.2 Normal Equation Methods
   3.3 Orthogonal Transformation Methods
   3.3.1 Transformation Idea
   3.3.2 Orthogonal/Unitary Matrices
   3.3.3 QR-Decomposition
   3.3.4 QR-Based Solver for Linear Least Squares Problems
   3.4 Singular Value Decomposition

4. Filtering Algorithms
   4.1 Filters and Convolutions
   4.2 Discrete Fourier Transform (DFT)
   4.3 Fast Fourier Transform (FFT)

5. Machine Learning of One-Dimensional Data
   (Data Interpolation and Data Fitting in 1D)
   5.1 Abstract Interpolation (AI)
   5.2 Global Polynomial Interpolation

8. Iterative Methods for Non-Linear Systems of Equations
   8.1 Introduction
   8.2 Iterative Methods
   8.3 Fixed-Point Iterations
   8.4 Finding Zeros of Scalar Functions
   8.5 Newton’s Method in Rn
   8.6. Quasi-Newton Method

Lecture notes
Lecture materials (PDF documents and codes) will be made available to the participants through the course web page and online repositories. Access information will be communicated in the beginning of the course.

Literature
W. Hanke-Bourgeois “Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

Prerequisites / notice
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves, in case they do not know it already.

Fostered competencies

263-5210-00L Probabilistic Artificial Intelligence

Abstract
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.

401-0647-00L Introduction to Mathematical Optimization

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Information about relevant literature will be given in the lecture.

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

### 227-0225-00L Linear System Theory

#### Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

#### Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

#### Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes Available on the course Moodle platform.

### 151-0575-01L Signals and Systems

#### Abstract
Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

#### Objective
Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

#### Content

Lecture notes Lecture notes available on course website.

### 252-0237-00L Concepts of Object-Oriented Programming

#### Abstract
Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection.

#### Objective
After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.

#### Content
The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying important challenges which are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

Literature Will be announced in the lecture.

### 262-6140-00L Random Processes: Theory and Applications from Physics to Finance

#### Abstract
Basics of probability theory; Random processes: General concepts; Markov processes: Master equation, Fokker-Planck equation, stochastic differential equations; Mathematical finance

#### Objective
Basics of the theory of stochastic processes and an overview of selected applications

### 262-6150-00L Programming for Life Sciences

#### Abstract
This course aims to train the students into the proficient use of programming in analyzing data derived from projects in life sciences. The format of the course includes 2 hour lectures, in which notions of software design and engineering will be discussed, and programming projects, done both in groups as well as individually.

#### Objective
By the end of the course, students should be comfortable with accessing and analyzing a wide variety of biological data. Concepts such as reproducibility, modularity, interoperability, and scalability will be emphasised.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>6</td>
<td>J. Lygeros, A. Tsiamis</td>
</tr>
<tr>
<td>151-0575-01L</td>
<td>Signals and Systems</td>
<td>4</td>
<td>A. Carron</td>
</tr>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>8</td>
<td>P. Müller</td>
</tr>
<tr>
<td>262-6140-00L</td>
<td>Random Processes: Theory and Applications from Physics to Finance</td>
<td>4</td>
<td>external organisers</td>
</tr>
<tr>
<td>262-6150-00L</td>
<td>Programming for Life Sciences</td>
<td>4</td>
<td>external organisers</td>
</tr>
</tbody>
</table>
Biology is becoming increasingly quantitative and mathematical modeling is now an integral part of biological research. In many biological processes, ranging from gene-expression to evolution, randomness plays an important role that can only be understood using stochastic models. This course will provide the students with a theoretical foundation for developing such stochastic models and analyzing them efficiently and consistently.

One can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects and problems. After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

Unfortunately, the quantity of data produced and available – now in the Zettabyte range (that's 21 zeros) per year – keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Does not take place this semester.

The first half of the course will cover the basics of Probability Theory while the second half will delve into the theory of Stochastic Processes. Below is the list of topics that will be covered in the course.

1. The mathematical representation of random phenomena: The probability space, properties of the probability measure, Independence of events, Conditional probability and Bayes formula, applications to parameter inference.


3. Convergence of Random Variables: Modes of convergence, Laws of large numbers, the central limit theorem, the law of the iterated logarithm, Applications to the analysis of cell population data.


While no specific textbook will be followed, much of the material and homework problems will be taken from the following books:


The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.

While no specific textbook will be followed, much of the material and homework problems will be taken from the following books:


The course will involve a healthy balance between mathematical rigor (theorem proving) and biological applications. Students are expected to have a good grasp of Linear Algebra and Multivariable Calculus. Basic knowledge of set theory will also be needed. Students should be prepared for abstract reasoning.

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The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Literature

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:

- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

### Fostered competencies

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Social Competencies**

- Communication
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

---

**Abstract**

Research in Biology and Medicine have been transformed into disciplines of applied data science over the past years. Not only size and inherent complexity of the data but also requirements on data privacy and complexity of search and access pose a wealth of new research questions.

**Objective**

This interactive course will explore the latest research on algorithms and data structures for population scale genomics applications and give insights into both the technical basis as well as the domain questions motivating it.
Content

Over the duration of the semester, the course will cover three main topics. Each of the topics will consist of 70-80% lecture content and 20-30% seminar content.

1) Algorithms and data structures for text and graph compression. Motivated through applications in compressive genomics, the course will cover succinct indexing schemes for strings, trees and general graphs, compression schemes for binary matrices as well as the efficient representation of haplotypes and genomic variants.

2) Stochastic data structures and algorithms for approximate representation of strings and graphs as well as sets in general. This includes winnowing schemes and minimizers, sketching techniques, (minimal perfect) hashing and approximate membership query data structures.

3) Data structures supporting encryption and data privacy. As an extension to data structures discussed in the earlier topics, this will include secure indexing using homomorphic encryption as well as design for secure storage and distribution of data.

Abstract

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).

(It is not required to buy the book, as the library has it)
### Applied Bioinformatics: Microbiomes

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>552-5500-00L</td>
<td>Applied Bioinformatics: Microbiomes</td>
<td>W</td>
<td>5</td>
<td>2V+2U</td>
<td>N. Bokulich</td>
</tr>
</tbody>
</table>

**Abstract**
Learn to apply practical bioinformatics/computational skills for analysis of microbiomes in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microbiomes to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

**Prerequisites / notice**

No specific pre-requisites, but students should have some familiarity with microbiology, molecular biology, programming (Python), bioinformatics, and statistics.

Students will bring and work on their own laptop computers.

All software used in the course is free and open-source.

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### Biology

At least 10 ECTS need to be acquired in this category.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>

**Abstract**
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**
This course focuses on the concepts of classical and modern genetics and genomics.

**Content**
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**
Scripts and additional material will be provided during the semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>551-0313-00L</td>
<td>Microbiology (Part I)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>W.-D. Hardt, L. Eberli, B. Nguyen, J. Piel, M. Pilhofer, A. Vagstad</td>
</tr>
</tbody>
</table>

**Abstract**
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.
Objective
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes
Updated handouts will be provided during the class.

Literature
Current literature references will be provided during the lectures.

Prerequisites / notice
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Instructor(s)</th>
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<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction into structural and functional aspects of the immune system.

**Objective**
Introduction into structural and functional aspects of the immune system.

**Content**
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien".

**Literature**
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

**Prerequisites / notice**
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**Fostered competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
  - Analytical Competencies: not assessed
  - Decision-making: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- Method-specific Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: assessed
  - Negotiation: not assessed

- Social Competencies

- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: assessed

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Instructor(s)</th>
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<td>636-0105-00L</td>
<td>Introduction to Biological Computers</td>
<td>4 credits</td>
<td>3G</td>
<td>Y. Benenson</td>
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</table>

**Abstract**
Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanothechnology and synthetic biology.

**Objective**
The course has the following objectives:

- Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms

- Introduce basic theories of computation

- Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include
- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly

* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations

* Foster creativity, research and communication skills through semester-long “Design challenge” assignment in the broad field of biological computing and biological circuit engineering.
Lecture 1. Introduction: what is molecular computation (part I)?

* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines

1st hour

* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour

* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation

* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4. Classical DNA computing

* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly

* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes

* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits

* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I

* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II

* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I

* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II

* RNAi logic circuits
* RNAi-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits

* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics

* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
Lecture notes
Lecture notes will be available online

As a way of general introduction, the following two review papers could be useful:


Benenson, Y. Biocomputers: from test tubes to live cells. Molecular Biosystems 2009, 5:675:685

Prerequisites / notice

636-0511-00L Developmental Neuroscience ■ W 2 credits 2V external organisers

Does not take place this semester.

Abstract
Development of cerebral cortex, hippocampus, motor system, olfactory system, visual system, auditory system, somatosensory system, navigation and memory systems, developmental disorders (autism, stem cells in the developing, adult and diseased brain.

636-0515-00L Molecular Medicine I ■ W 2 credits 2V external organisers

Abstract
This lecture series will introduce biologists to the mechanisms that cause human diseases. Emphasis will be on the genetic and environmental factors that lead to diseases, and how this knowledge can be used to develop diagnostic and therapeutic procedures.

262-6170-00L Molecular Mechanisms of Development ■ W 2 credits 2V external organisers

Abstract
This lecture will present examples for developmental switches in a variety of systems, including single-cell organisms, plants, nematodes, flies and vertebrates. The lecture will illustrate a way of thinking rather than attempt to cover single details of the issues discussed.

262-6180-00L Molecular Control of Vertebrate Development and Organogenesis ■ W 2 credits 2V external organisers

Abstract
This course will introduce the participants to the basic principles, genetic tools and vertebrate model systems used to study developmental processes.

262-5130-00L Evolutionary Medicine: Morphological Changes and Pathologies (University of Zurich) W 6 credits 5G University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO440

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Objective
The course addresses aspects of this transdisciplinary research in lectures and provides opportunity to perform small research projects in the fields of paleogenetics, palaeopathology, imaging technologies, long- and short- term morphological changes.

262-6101-00L New Approaches to Tackle Antibiotic Resistance W 1 credit 1V external organisers

Abstract
This lecture series was redesigned in the scope of the recently established Swiss-wide research network on antibiotics called AntiResist.Internationally renowned scientists from different disciplines present their latest findings and discuss how their work relates to a better understanding of infection processes and antibiotic therapy.

262-6102-00L Functional Organization of the Cell Nucleus ■ W 2 credits 2V external organisers

Abstract
This course will describe the structure and function of the eukaryotic nucleus. In this course, all features of the nucleus from regulated import/export through pores, to the compartmentalization of transcription, splicing, replication and repair will be covered. The lectures will give an up-to-date overview of a complex structure-function problem that touches on crucial aspects of cell identity.

262-6103-00L Cellular Signalling ■ W 2 credits 2V external organisers

Abstract
This course gives an introduction into cellular signalling mechanisms, followed by specific topics covering tyrosine/threonine kinase growth factor receptors, protein/protein and protein/lipid interaction modules, signalling by Ras family G proteins, lipid kinases, phospholipid-coupled transduction systems, protein kinase C, G protein-coupled receptors, and other topics.

262-6105-00L Frontiers in RNA Biology ■ W 2 credits 2V external organisers

Does not take place this semester.

Abstract
The lecture will cover the following topics: chemistry and structure of RNA; major classes of cellular RNAs, chemistry and structure of RNA; pre-mRNA processing with emphasis on splicing and polyadenylation; biogenesis of tRNA and rRNA; biochemistry and function of RNA interference (RNAi) and microRNAs; RNA trafficking in the cell; RNA quality control and RNA degradation; and more.

636-0109-00L Stem Cells: Biology and Therapeutic Manipulation W 4 credits 3G T. Schroeder

Abstract
Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

Objective
Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

Content
We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical biology of proteins will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content

Lecture notes
Handout during the course.

262-5120-00L Principles of Evolution: Theory (University of Zurich) W 6 credits 3V University lecturers
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: BIO351

Abstract
“Nothing in Biology Makes Sense Except in the Light of Evolution”. Evolutionary theory and methods are essential in all branches of modern biology.

Objective
Subject specific skills:
By the end of the course, students will be able to:
o describe basic evolutionary theory and its applications
o discuss ongoing debates in evolutionary biology
o critically assess the presentation of evolutionary research in the popular media

Key skills:
By the end of the course, students will be able to:
o approach biological questions from an evolutionary perspective

Content
This course will provide a broad overview of current evolutionary thought, including the mechanisms of evolutionary change, adaptation and the history of life and will involve practical field and lab work as well as lecture material.

Lecture notes
Handout during the course.

551-0307-00L Molecular and Structural Biology I: Protein Structure and Function W 3 credits 2V R. Glockshuber, K. Locher, E. Weber-Ban

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biophysics and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysical methods as well as modern methods for protein purification and microanalysis.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Current topics: References will be given during the lectures.

262-6107-00L Applied Mathematics and Informatics in Drug Discovery W 2 credits 2G external organisers

Abstract
This introductory course will offer a practitioner's review of mathematical concepts, informatics tools, and industrial approaches in relevant fields, especially bioinformatics, molecular modelling, cheminformatics, mathematical modelling, experiment design and statistical inference, and machine learning.

Objective
We explore the drug-discovery process and study applications of mathematics and informatics with case studies. We examine how mathematics concepts and informatics tools are used to model complex systems at multiple levels - molecular level, cellular and omics level, organ- and system-level, and population level - and how the multiscale modelling approach contributes to drug discovery.

529-0733-02L Chemical Biology and Synthetic Biochemistry W 6 credits 3G K. Lang

Abstract
Overview of modern chemical biology and synthetic biochemistry techniques, focussed on protein modification and labeling and on methods to endow proteins with novel functionalities.

Objective
After taking this course, students should be capable of the following: A) Recall different possibilities for modifying proteins in vitro and in vivo and their applications in a biological context, B) Understand the chemical and biochemical consequences of modifications and assess the different reaction possibilities in the context of in vivo - in vitro, C) Critically analyze and assess current chemical biology articles D) Question the approaches learned and apply them to new biological problems.
Content 

principles of protein labeling and protein modification (fluorescent proteins, enzyme-mediated labeling, bioorthogonal chemistries);
principles of genetic code expansion (amber suppression, orthogonal ribosomes, unnatural base pairs, genome engineering and genome editing);
chemical biology of ubiquitin and targeted protein degradation

Lecture notes 

A script will not be handed out. Handouts to the lecture will be provided through moodle.

Literature 

Citations from the original literature relevant to the individual lectures will be assigned during the lectures.

Prerequisites / notice 

Knowledge provided in the bachelor lectures 'Nucleic Acids and Carbohydrates' and 'Proteins and Lipids' is assumed for this lecture.

Fostered competencies 

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Lab Rotations 

Students starting before Autumn Semester 2021:
18 ECTS in total (262-01*).

At least one lab rotation in different group/ supervisor than master’s thesis.

Either choose Lab Rotation Short 1 and Lab Rotation Long 2 (9 ECTS)

Or choose Lab Rotation Short 1 and Industry Internship (12 ECTS)

Or choose Lab Rotation Short 1 and Industry Internship Short (each 6 weeks, 9 ECTS)

Or Industry Internship Long (12 weeks, 18 ECTS)

Students starting in Autumn Semester 2021 or later:
18 ECTS in total (262-03*).

At least two lab rotations need to be completed in two different research groups (supervisors).

Either choose Lab Rotation Short 1 (6 ECTS) and Lab Rotation Short 2 (6 ECTS) and Lab Rotation Short 3 (6 ECTS)

Or choose Lab Rotation Short 1 (6 ECTS) and Industry Internship (12 ECTS)

Or choose Lab Rotation Short 1 (6 ECTS) and Industry Internship Short (each 6 weeks, 9 ECTS)

Or Industry Internship Long (12 weeks, 18 ECTS)

Number  Title  Type  ECTS  Hours  Lecturers

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<thead>
<tr>
<th>262-0100-00L</th>
<th>Lab Rotation Short 1</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>Abstract Objective</td>
<td>Flexible short research project of 4 weeks, completed with a written report.</td>
<td>Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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<td>Abstract Objective</td>
<td>Flexible short research project of 4 weeks, completed with a written report.</td>
<td>Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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<tbody>
<tr>
<td>Abstract Objective</td>
<td>Flexible short research project of 4 weeks, completed with a written report.</td>
<td>Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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<tr>
<td>Abstract Objective</td>
<td>Flexible short research project of 6 weeks, completed with a written report.</td>
<td>Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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<tr>
<td>Abstract Objective</td>
<td>Flexible short research project of 6 weeks, completed with a written report.</td>
<td>Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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<th>12 credits</th>
<th>26A</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>Abstract Objective</td>
<td>Industry internship of at least 8 weeks, completed with a written report.</td>
<td>The students look for a placement themselves.</td>
<td>Students gain experience in an industrial environment and an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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<table>
<thead>
<tr>
<th>262-0106-00L</th>
<th>Lab Rotation Long 3</th>
<th>W</th>
<th>12 credits</th>
<th>26A</th>
<th>Lecturers</th>
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<td>Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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<td>Abstract Objective</td>
<td>Flexible short research project of 6 weeks, completed with a written report.</td>
<td>Students gain an overview of different research areas by applying concepts taught in the core courses and advanced courses.</td>
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</table>
Fundamental algorithms and data structures are presented and analyzed. Firstly, this comprises design paradigms for the development of algorithms such as induction, divide-and-conquer, backtracking, dynamic programming and classical algorithmic problems such as searching and sorting.

Moreover, an introduction to parallel programming is provided. The programming model of C++ will be discussed in some depth. In the part about parallel programming, parallel architectures are discussed conceptually (multicore, vectorization, pipelining). Parallel programming concepts are presented (Amdahl's and Gustavson's laws, task/data parallelism, scheduling). Problems of concurrency are analyzed (Data races, deadlocks, memory reordering). Process synchronisation and communication in a shared memory system is explained (mutual exclusion, semaphores, monitors, condition variables). Progress conditions are analysed (freedom from deadlocks, starvation, lock- and wait-freedom). The concepts are underpinned with examples of concurrent and parallel programs and with parallel algorithms.

The programming model of C++ is discussed in some depth. The RAII (Resource Allocation is Initialization) principle will be explained. Exception handling, functors and lambda expression and generic programming with templates are further examples of this part. The implementation of parallel and concurrent algorithm with C++ is also part of the exercises (e.g. threads, tasks, mutexes, condition variables, promises and futures).
Wir behandeln fundamentale Datentypen, Ausdrücke und Anweisungen, (Grenzen der) Computerarithmetik, Kontrollanweisungen.


Primäres Lernziel der Vorlesung ist die Befähigung zum Programmieren mit C++. Studenten beherrschen nach erfolgreichem Abschluss der Vorlesung die Mechanismen zum Erstellen eines Programms, sie kennen die fundamentalen Kontrollstrukturen, Datenstrukturen und verstehen, wie man ein algorithmisches Problem in ein Programm abbildet. Sie haben eine Vorstellung davon, was "hinter den Kulissen" passiert, wenn ein Programm übersetzt und ausgeführt wird.

Die Konzepte der Vorlesung werden jeweils durch Algorithmen und Anwendungen motiviert und illustriert.

Ein Skript in englischer Sprache wird semesterbegleitend herausgegeben. Das Skript und die Folien werden auf der Vorlesungshomepage zum Herunterladen bereitgestellt.

The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

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Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics: DNA, chromosomes, RNA, protein, genetics, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer, development and stem cells.

Literature

636-1005-AAL Bio V: Bioinformatics E- 5 credits 7R N. Beererwinkel

Does not take place this semester. Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Literature
Pevsner J, Bioinformatics and Functional Genomics, 3rd edition, 2015, chapters 1–7

Computational Biology and Bioinformatics Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
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<td>W</td>
<td>Eligible for credits</td>
<td>Suitable for doctorate</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>Compulsory</td>
<td></td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>Eligible for credits and recommended</td>
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Key for Hours

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<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
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<tr>
<td>P</td>
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<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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<tr>
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<td>D</td>
<td>R</td>
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ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Cyber Security Master

### Field of Specialization

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>D. Basin, M. Ochoa Ronderos</td>
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</tbody>
</table>

**Abstract**

Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

**Objective**

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include:

- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems.
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - ISO/IEC 27000
    - NIST special papers
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security

Abstract
The first part of the course covers general security concepts and hardware-based support for security.

In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.
Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-4640-00L  
**Network Security**  

| W | 8 credits | 2V+2U+3A | A. Perrig, S. Frei, M. Legner, K. Paterson |

**Abstract**
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

This course provides an in-depth study of network attack techniques and methods to defend against them.

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

**Objective**
The course will cover topics spanning four broad themes with a focus on the first two themes:

(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;

(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;

(3) analysis and inference topics such as traffic monitoring and network forensics; and

(4) new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

**Prerequisites / notice**
Basic knowledge of information security or applied cryptography, as taught in 252-0211-00L or 263-4660-00L, is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

**Content**
- Students can implement network-security protocols based on cryptographic libraries.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can implement network-security protocols based on cryptographic libraries.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
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**Social Competencies**

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<th>Communication</th>
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</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
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<tr>
<td>Leadership and Responsibility</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Negotiation</td>
<td>not assessed</td>
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</table>

**Personal Competencies**

<table>
<thead>
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<th>Adaptability and Flexibility</th>
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<tbody>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</tbody>
</table>

**Autumn Semester 2022**

263-4640-00L  
**Advanced Topics in Communication Networks**  

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0575-00L</td>
<td>Advanced Topics in Communication Networks</td>
<td>W</td>
<td>6</td>
<td>2+2</td>
<td>L. Vanbever, R. Jacob</td>
</tr>
</tbody>
</table>

**Abstract**
This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover new technologies related to next-generation networks.

**Objective**
The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.

**Content**
The course will cover advanced topics in Internet routing and forwarding such as:

- Tunneling
- Hierarchical routing
- Traffic Engineering and Load Balancing
- Virtual Private Networks
- Quality of Service/Queuing/Scheduling
- Fast Convergence
- Network virtualization
- Network programmability (OpenFlow, P4)
- Network measurements

The course will be divided into two main blocks. The first block (~8 weeks) will interleave classical lectures with practical exercises and labs. The second block (~6 weeks) will consist of a practical project which will be performed in small groups (~3 students). During the second block, lecture slots will be replaced by feedback sessions where students will be able to ask questions and get feedback about their project.

The last week of the semester will be dedicated to student presentations and demonstrations.
This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.

By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:

- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.
- writing critical reviews and constructive discussions with peers on this topic.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature

Slides, relevant literature and manuals will be made available during the course.

Prerequisites / notice

Experience with Linux, systems programming and computer architecture.

Lecture notes


Literature

Recommended reading includes:

- Various: OWASP Guide to Building Secure Web Applications, available online
- O'Reilly, Loukides: Unix Power Tools, O'Reilly & Associates.
- Frisch: Essential System Administration, O'Reilly & Associates.
- NIST: Risk Management Guide for Information Technology Systems, available online as PDF
- BSI: IT-Grunschutzhandbuch, available online

Prerequisites / notice

- The lab allows flexible working since there are only few mandatory meetings during the semester.
- The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas: information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.
- Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the recommended requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.
- All participants must sign the lab's charter and usage policy during the introduction lecture.

Lecture notes

Lecture notes and material will be made available before each course on the course website.

Literature

Relevant references will be made available through the course website.

Prerequisites / notice

Prerequisites: Communication Networks (227-0120-00L) or equivalents / good programming skills (in any language) are expected as both the exercises and the final project will involve coding.
Abstract
Public-Key Encryption has had a significant impact by enabling remote parties to communicate securely via an insecure channel. Latest schemes go further by providing a fine-grained access to the encrypted data.

Objective
The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.

Content
We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Literature
Links to relevant research papers will be given in the course materials.

Prerequisites / notice
It is recommended for students to have prior exposure to cryptography, e.g. the D-INFK course "Digital Signatures" or "Applied Cryptography".

Zero-Knowledge Proofs

W 5 credits 2V+1U+1A J. Bootle

Abstract
Zero-knowledge proofs are protocols which allow a prover to convince a verifier that a statement is true without leaking any information beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.

Objective
- To understand what it means for a zero-knowledge proof to be secure
- To construct and analyse various types of zero-knowledge proofs
- To understand some advanced applications of zero-knowledge proofs

Content
The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in cryptography and the real world. The course may also describe some more advanced constructions of non-interactive proofs.

Lecture notes
The course notes will be written in English.

Prerequisites / notice
Students should have taken a first course in Cryptography (as taught in the Information Security course at Bachelor's level). Experience with algebra and probability is desirable.

Seminar

Current Topics in Information Security

W 2 credits 2S S. Capkun, K. Paterson, A. Perrig, S. Shinde

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
The seminar covers various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.

Objective
The main goals of the seminar are the independent study of scientific literature and assessment of its contributions as well as learning and practicing presentation techniques.

Content
The seminar covers various topics in information security, including network security, cryptography and security protocols. The participants are expected to read a scientific paper and present it in a 35-40 min talk. At the beginning of the semester a short introduction to presentation techniques will be given.

Selected Topics
- security protocols: models, specification & verification
- trust management, access control and non-interference
- side-channel attacks
- identity-based cryptography
- host-based attack detection
- anomaly detection in backbone networks
- key-management for sensor networks

Literature
The reading list will be published on the course web site.

Semester Project

Semester Project

W 12 credits 26A Professors

Abstract
The Semester Project provides students with the opportunity to apply acquired knowledge and skills.

Objective
The students can gain hand-on experience by solving independently a technical-scientific problem.

Prerequisites / notice
Prerequisites: At least one core course in Cyber Security and one inter focus course must have been completed successfully.

Minor

Data Management Systems

Core Courses

Big Data

W 10 credits 3V+2U+4A G. Fourny

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.
Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

“Big Data” refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm”.

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

Content
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice
The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- “Information Systems for Engineers” (SQL, relational databases): this Fall
- “Big Data for Engineers” (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving

- **Social Competencies**
  - Communication
  - Sensitivity to Diversity
  - Negotiation

- **Personal Competencies**
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics

**263-3845-00L Data Management Systems**

<table>
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<tbody>
<tr>
<td>8 credits</td>
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</table>

**ECTS**

- 3V+1U+3A
- G. Alonso

**Abstract**
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

**Objective**
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

**Content**
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

**Literature**
The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

**Prerequisites / notice**
The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies

**Elective Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

**Content**
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - MAX Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

**Lecture notes**
No lecture notes, but slides will be made available on the course webpage.

**Literature**


**Prerequisites / notice**
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
System Security

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

Informal Methods

Abstract
Formal methods are increasingly a key part of the methodological toolkit of systems programmers - those writing operating systems, software systems, and how to get into the habit of thinking formally about systems design even when writing low-level C code.

Objective
This course does not assume prior knowledge of formal methods, and will start with a quick review of topics such static vs. dynamic reasoning, variants and invariants, program algebra and refinement, etc. However, it is strongly recommended that students have already taken one of the introductory formal methods course at ETH (or equivalents elsewhere) before taking this course - the emphasis is on reinforcing these concepts by applying them, not to teach them from scratch.

Content
Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified sel4 microkernell will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).
# Machine Intelligence

## Core Courses

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>252-0535-00L</td>
<td><strong>Advanced Machine Learning</strong></td>
<td>W</td>
<td><strong>10 credits</strong></td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

### Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

### Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

### Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

#### Topics covered in the lecture include:

- **Fundamentals:**
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- **Supervised learning:**
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- **Unsupervised learning:**
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

### Lecture notes

No lecture notes, but slides will be made available on the course webpage.

### Literature


### Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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<tbody>
<tr>
<td>263-3210-00L</td>
<td><strong>Deep Learning</strong></td>
<td>W</td>
<td><strong>8 credits</strong></td>
<td>3V+2U+2A</td>
<td>T. Hofmann, F. Perez Cruz, N. Perraudin</td>
</tr>
</tbody>
</table>

### Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

### Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

### Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://ias.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://ias.inf.ethz.ch/teaching/pai-f18

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 578 of 2416
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study these and other applied engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

The course is split into 3 parts:

Robustness in Deep Learning
- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning
- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning
- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.

For solving assignments, some programming experience in Python is expected.

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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>Solid basic knowledge in statistics, algorithms and programming.</td>
</tr>
<tr>
<td>The material covered in the course &quot;Introduction to Machine Learning&quot; is considered as a prerequisite.</td>
</tr>
</tbody>
</table>

### Elective Courses

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-3005-00L</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7 credits</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.</td>
</tr>
</tbody>
</table>

### Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5005-00L</td>
<td>Artificial Intelligence in Education</td>
<td>W</td>
<td>3 credits</td>
<td>1V+0.5U</td>
<td>M. Sachan, T. Sinha</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.</td>
</tr>
</tbody>
</table>

### Prerequisites / notice

- Solid basic knowledge in statistics, algorithms and programming.
- The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 579 of 2416
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture slides will be made available at the course Web site. No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

263-5255-00L Foundations of Reinforcement Learning

This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes Lecture notes will be posted on Moodle.

Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Csaba Czepesvári.

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5300-00L Guarantees for Machine Learning

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Linear Regression”/“Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)
This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data. The course is a year-long journey, but the second half (Spring 2023) does not depend on the first (Fall 2022) and thus either half may be taken independently. In each semester, we divide the class time into three modules. Each module is centered around a philosophical topic. In the first semester we will discuss structuralism, recursive structure and logic, and in the second semester we will focus on language games, information and pragmatics. The modules will be four weeks long. During the first two weeks of a module, we will read and discuss original texts and supplementary criticism. During the second two weeks, we will read recent NLP papers and discuss how the authors of those works are building on philosophical insights into our conception of language—perhaps implicitly or unwittingly.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philosophy of Language and Computation</td>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>263-5353-00L</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**Abstract**
Understand the philosophical underpinnings of language-based artificial intelligence.

**Objective**
This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data.

**Content**
This graduate class, taught like a seminar, is designed to help you understand the philosophical underpinnings of modern work in natural language processing (NLP), most of which centered around statistical machine learning applied to natural language data. The course is a year-long journey, but the second half (Spring 2023) does not depend on the first (Fall 2022) and thus either half may be taken independently. In each semester, we divide the class time into three modules. Each module is centered around a philosophical topic. In the first semester we will discuss structuralism, recursive structure and logic, and in the second semester we will focus on language games, information and pragmatics. The modules will be four weeks long. During the first two weeks of a module, we will read and discuss original texts and supplementary criticism. During the second two weeks, we will read recent NLP papers and discuss how the authors of those works are building on philosophical insights into our conception of language—perhaps implicitly or unwittingly.

**Literature**
The literature will be provided by the instructors on the class website.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>A. Steger</td>
</tr>
</tbody>
</table>

**Abstract**
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

**Objective**
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Lecture notes**
Yes.

**Literature**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

**Content**
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

**Topics covered in the lecture include:**
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.


Solid background in linear algebra.

 Former course title: Mathematical Optimization.

<table>
<thead>
<tr>
<th>Assessed</th>
<th>Not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
</tr>
<tr>
<td>Project Management</td>
<td>Social Competencies</td>
</tr>
</tbody>
</table>

Communication

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”, “Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 583 of 2416
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main objectives of this course are:

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture topics from the lecture will be implemented into a 3D game or a comparable application.

The programming assignments will be in C++. This will not be taught in the class. It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0543-01L</td>
<td>Computer Graphics</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>M. Gross, M. Papas</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.</td>
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</tbody>
</table>

#### Objective

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

#### Content

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

The programming assignments will be in C++. This will not be taught in the class.

### Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0546-00L</td>
<td>Physically-Based Simulation in Computer Graphics</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U+1A</td>
<td>S. Coros, B. Thomaszewski, V. da Costa de Azevedo</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.</td>
<td></td>
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</table>

#### Objective

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

#### Content

The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

The programming assignments will be in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0546-00L</td>
<td>Mixed Reality</td>
<td>W</td>
<td>5 credits</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
</tr>
<tr>
<td>Abstract</td>
<td>The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.</td>
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</table>

#### Objective

After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

#### Content

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Data: 01.11.2022 12:41
Autumn Semester 2022
Prerequisites / notice

Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

<table>
<thead>
<tr>
<th>Interfocus Courses</th>
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<tbody>
<tr>
<td><strong>Number</strong></td>
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<tr>
<td>263-0006-00L</td>
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</tbody>
</table>

**Abstract**

Students learn how to solve algorithmic problems given by a textual description (understanding problem setting, finding appropriate modeling, choosing suitable algorithms, and implementing them). Knowledge of basic algorithms and data structures is assumed; more advanced material and usage of standard libraries for combinatorial algorithms are introduced in tutorials.

**Objective**

The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem modeling, choice of suitable (combinatorial) algorithms, and implementing them (using C/C++, STL, CGAL, and BGL).

**Literature**


<table>
<thead>
<tr>
<th>Interfocus Courses</th>
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</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
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<tr>
<td>263-0009-00L</td>
</tr>
</tbody>
</table>

**Abstract**

This InterFocus Course will provide a broad, hands-on introduction to Information Security, introducing adversarial thinking and security by design as key approaches to building secure systems.

**Objective**

This course will introduce key concepts from Information Security, both from attack and defence perspectives. Students will gain an appreciation of the complexity and challenge of building secure systems.

**Content**

The course is organised in two-week segments. In each segment, a new concept from Information Security will be introduced. The overall scope will be broad, including cryptography, protocol design, network security, system security.

**Lecture notes**

Will be made available during the semester.

**Literature**

Paul C. van Oorschot, Computer Security and the Internet: Tools and Jewels.
Dan Boneh and Victor Shoup, A Graduate Course in Applied Cryptography.

**Prerequisites / notice**

Ideally, students will have taken the D-INFK Bachelors course "Information Security" or an equivalent course at Bachelors level.

<table>
<thead>
<tr>
<th>Free Electives</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Master level courses offered by ETH Zurich, EPF Lausanne and the University of Zurich may be chosen.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science in Perspective</th>
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<tbody>
<tr>
<td>see Science in Perspective: Type A: Enhancement of Reflection Capability</td>
</tr>
</tbody>
</table>

**Recommended Science in Perspective (Type B) for D-INFK**

| see Science in Perspective: Language Courses ETH/UZH |

<table>
<thead>
<tr>
<th>Internship</th>
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<tbody>
<tr>
<td><strong>Number</strong></td>
</tr>
<tr>
<td>260-0700-00L</td>
</tr>
</tbody>
</table>

**Abstract**

An Internship provides opportunities to gain experience in an industrial environment and it creates a network of contacts.

<table>
<thead>
<tr>
<th>Master's Thesis</th>
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<tbody>
<tr>
<td><strong>Number</strong></td>
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<tr>
<td>260-0800-00L</td>
</tr>
</tbody>
</table>

**Abstract**

The Master's thesis concludes the study program and demonstrates the students' ability to use the knowledge and skills acquired during Master's studies to solve a complex cyber security problem.

**Objective**

To work independently and to produce a scientifically structured work.

<table>
<thead>
<tr>
<th>Cyber Security Master - Key for Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td><strong>W</strong> Eligible for credits</td>
</tr>
<tr>
<td><strong>E-</strong> Recommended, not eligible for credits</td>
</tr>
<tr>
<td><strong>Z</strong> Courses outside the curriculum</td>
</tr>
</tbody>
</table>
### Key for Hours

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
DAS in Applied Statistics

Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>447-0649-01L</td>
<td>Applied Statistical Regression I</td>
<td>O</td>
<td>4 credits</td>
<td>1V+1U</td>
<td>L. Meier</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>Simple and multiple regression models, with emphasis on practical aspects and interpretation of results, analysis of residuals and model selection.</td>
<td></td>
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</tr>
<tr>
<td>447-0649-02L</td>
<td>Applied Statistical Regression II</td>
<td>O</td>
<td>2 credits</td>
<td>1V+1U</td>
<td>L. Meier</td>
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<td>Only for DAS and CAS in Applied Statistics.</td>
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<tr>
<td>Abstract</td>
<td>Generalized linear models (GLMs) and basic ideas of more advanced regression models.</td>
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<tr>
<td>Objective</td>
<td>Understanding the concept and flexibility of generalized linear models and correct interpretation of the corresponding model outputs.</td>
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<tr>
<td>447-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design I</td>
<td>O</td>
<td>3 credits</td>
<td>1V+1U</td>
<td>L. Meier</td>
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<tr>
<td>Abstract</td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs.</td>
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<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<tr>
<td>447-6201-00L</td>
<td>Nonparametric and Resampling Methods</td>
<td>O</td>
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<tr>
<td>Abstract</td>
<td>Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.</td>
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<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Understanding of the choice of weight function and of the smoothing parameter, also done automatically. Focus is on one dimension, higher dimensions and samples of curves are treated briefly. Exercises at the computer.</td>
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</tr>
<tr>
<td>Content</td>
<td>Nonparametric tests, randomization tests, jackknife and bootstrap, as well as asymptotic properties of estimators.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>This course is part of the programme for the certificate and diploma in Advanced Studies in Applied Statistics. It is given every second year in the winter semester break.</td>
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<tr>
<td>447-0990-00L</td>
<td>Workshop</td>
<td>O</td>
<td>1 credit</td>
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<td></td>
<td>Only for DAS in Applied Statistics.</td>
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<tr>
<td>Abstract</td>
<td>In the workshop each participant gives a short talk about a recent statistical problem encountered in their daily work.</td>
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<tr>
<td>Objective</td>
<td>Presentation of a statistical problem, getting to know different applications of statistical methodology.</td>
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Electives

<table>
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<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>447-0625-02L</td>
<td>Applied Analysis of Variance and Experimental Design II</td>
<td>W</td>
<td>3 credits</td>
<td>1V+1U</td>
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<td>Only for DAS and CAS in Applied Statistics.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<tr>
<td>Objective</td>
<td>Participants will be able to plan and analyze sophisticated experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<tr>
<td>447-6221-00L</td>
<td>Nonparametric Regression</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>M. Mächler</td>
</tr>
<tr>
<td></td>
<td>Special Students &quot;University of Zurich (UZH)&quot; in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to <a href="mailto:registrar@ethz.ch">registrar@ethz.ch</a>. The Registrar's Office will then register you for the course.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>This course focuses on nonparametric estimation of probability densities and regression functions. These recent methods allow modelling without restrictive assumptions such as 'linear function'. These smoothing methods require a weight function and a smoothing parameter. Focus is on one dimension, higher dimensions and samples of curves are treated briefly. Exercises at the computer.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Knowledge on estimation of probability densities and regression functions via various statistical methods. Understanding of the choice of weight function and of the smoothing parameter, also done automatically. Practical application on data sets at the computer.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies Concepts and Theories assessed</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Method-specific Competencies Analytical Competencies assessed</td>
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</tr>
<tr>
<td></td>
<td>Media and Digital Technologies Problem-solving assessed</td>
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<tr>
<td></td>
<td>Personal Competencies Creative Thinking assessed</td>
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<tr>
<td>447-6257-00L</td>
<td>Repeated Measures</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
<td>L. Meier</td>
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<tr>
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<td>Special Students &quot;University of Zurich (UZH)&quot; in the</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 587 of 2416
Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<th>Instructor</th>
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<tbody>
<tr>
<td>447-6289-00L</td>
<td>Sampling Surveys</td>
<td>W</td>
<td>2</td>
<td>B. Hulliger</td>
</tr>
<tr>
<td>447-6265-00L</td>
<td>Deep Learning: A Probabilistic Approach</td>
<td>W</td>
<td>2</td>
<td>O. Dürr, B. Sick</td>
</tr>
<tr>
<td>447-6233-00L</td>
<td>Spatial Statistics</td>
<td>W</td>
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</tbody>
</table>

**Abstract**


**Objective**

Participants will gain the ability of recognizing repeated measures and to analyze them adequately. They will know how to deal with pseudoreplicates.

**Course Code**

<table>
<thead>
<tr>
<th>447-6289-00L Sampling Surveys</th>
<th>W</th>
<th>2 credits</th>
<th>1G</th>
<th>B. Hulliger</th>
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<tbody>
<tr>
<td>447-6265-00L Deep Learning: A Probabilistic Approach</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>O. Dürr, B. Sick</td>
</tr>
<tr>
<td>447-6233-00L Spatial Statistics</td>
<td>W</td>
<td>1 credit</td>
<td>1G</td>
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</tbody>
</table>

**Abstract**

The elements of a sample survey are explained. The most important classical sample designs (simple random sampling and stratified random sampling) with their estimation procedures and the use of auxiliary information including the Horvitz-Thompson estimator are introduced. Data preparation, non-response and its treatment, variance estimation and analysis of survey data is discussed.

**Objective**

Knowledge of the Elements and the process of a sample survey. Understanding of the paradigm of random samples. Knowledge of simple random sampling and stratified random sampling and capability to apply the corresponding methods. Knowledge of further methods of sampling and estimation as well as data preparation and analysis.

**Lecture notes**

Introduction to the statistical methods of survey research

**Content**

After an introductory discussion of the types of problems and the kind of data that arise in environmental research, an introduction into linear geostatistics (models: stationary random processes, modelling large-scale spatial patterns by regression, modelling autocorrelation by variogram; Kriging: mean-square prediction of spatial data) will be taught. The lectures will be complemented by data analyses that the participants have to do themselves.

**Literature**

### Analytical Competencies

<table>
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<th>Assessment</th>
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<tbody>
<tr>
<td>Street competence</td>
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<tr>
<td>Decision-making</td>
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</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
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<td>Project Management</td>
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### Social Competencies

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<th>Assessment</th>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Negotiation</td>
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### Personal Competencies

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<tbody>
<tr>
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<tr>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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#### 447-6273-00L

**Applied Bayesian Statistics**

- **W**
- **2 credits**
- **2G**
- **S. Robert**

Special Students "University of Zurich (UZH)"* in the Master Program in Biostatistics at UZH cannot register for this course unit electronically. Forward the lecturer's written permission to attend to the Registrar's Office. Alternatively, the lecturer may also send an email directly to registrar@ethz.ch. The Registrar's Office will then register you for the course.

**Abstract**

Introduction to Bayesian statistics: basics of inference, computation with MCMC, linear logistic regression, Bayesian hierarchical models. Focus on applications and hands-on programming.

**Objective**

- understand the basics of Bayesian inference
- use R packages to run MCMC algorithms
- fit and understand Bayesian linear models
- introduction to hierarchical Bayesian models

**Content**

We will learn how to describe business/scientific problems as probabilistic models, apply Bayes rules to draw inference from data, and use the probabilistic programming language STAN to obtain samples from posterior distributions. On the way we will fit linear models both for continuous and categorical outcomes, and explore techniques to deal with hierarchical structures in the data.

There will be examples of applications from various fields: insurance, meteorology, marketing, etc.

**Literature**

*"Bayes Rules! An Introduction to Applied Bayesian Modeling*, Alicia A. Johnson, Miles Q. Ott, Mine Dogucu - CRC Press 2022

**Prerequisites**

- introductory statistics
- applied regression
- **R**

---

#### 447-6191-00L

**Statistical Analysis of Financial Data**

- **W**
- **2 credits**
- **1G**
- **M. Dettling, A. F. Ruckstuhl**

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**Abstract**


**Objective**

Getting to know the typical properties of financial data and appropriate statistical models, incl. the corresponding functions in R.

**Prerequisites**

- **R**

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#### 447-6255-00L

**Analysis of High-Dimensional Data**

- **W**
- **1 credit**
- **1G**
- **N. Stadler**

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**Abstract**

Block course on analysis of high-dimensional data with a focus on prediction and feature assessment.

**Objective**

The goal of this course is to gain a good understanding of the concepts discussed during the lecture and to apply the new methods on real data examples using the software **R**. The topics covered in the lecture are:

**Part 1:** Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularisation

**Part 2:** Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

**Content**

Course on Analysis of High-Dimensional Data with focus on Prediction and Feature Assessment.

**Part 1:** Linear regression in the high-dimensional context; Overfitting, prediction and the bias-variance tradeoff; Model selection; Ridge and Lasso regularisation

**Part 2:** Logistic regression and regularization; Classification based on decision trees, Random Forest and AdaBoost; Multiple testing; P-value adjustment and variance shrinkage

**Lecture notes**

The block course is based on lecture notes ([https://bookdown.org/staedler_n/highdimstats/](https://bookdown.org/staedler_n/highdimstats/)).

Prerequisites / notice
The exercises are done exclusively with the (free, open source) software "R" ([http://www.r-project.org](http://www.r-project.org)). A final exam will also happen at the computers, using R (and your brains!).

Fostered competencies

<table>
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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Technique and Technologies</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Cooperation and Teamwork</td>
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<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
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<tbody>
<tr>
<td>Creative Thinking</td>
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<tr>
<td>Self-direction and Self-management</td>
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<td>not assessed</td>
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<table>
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<tr>
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Diploma Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>447-1990-00L</td>
<td>Diploma Thesis</td>
<td>O</td>
<td>2</td>
<td>4D</td>
<td>Supervisors</td>
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</tbody>
</table>

Abstract
The diploma thesis typically consists of a data analysis of data from a participant's own field of work. The thesis requires a time expenditure of about one or two weeks. Thesis work should prove the participants' capability to apply useful and modern statistical methods to address appropriate questions properly and effectively.

Objective
Thesis work should prove the participants' capability to apply useful and modern statistical methods to address appropriate questions properly and effectively.

DAS in Applied Statistics - Key for Type

<table>
<thead>
<tr>
<th>DAS</th>
<th>Description</th>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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</table>

Key for Hours

| V     | lecture                                         |
| G     | lecture with exercise                           |
| U     | exercise                                        |
| S     | seminar                                         |
| K     | colloquium                                      |
| P     | practical/laboratory course                    |
| A     | independent project                             |
| D     | diploma thesis                                  |
| R     | revision course / private study                 |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
DAS in Cyber Security

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>O</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>S. Capkun, S. Shinde</td>
</tr>
<tr>
<td>Abstract</td>
<td>The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone). In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety). Along the lectures, model cases will be elaborated and evaluated in the exercises.</td>
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</tr>
<tr>
<td>263-4640-00L</td>
<td>Network Security</td>
<td>O</td>
<td>8</td>
<td>2V+2U+3A</td>
<td>A. Perrig, S. Frei, M. Legner, K. Paterson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.</td>
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<tr>
<td>Objective</td>
<td>- Students are familiar with fundamental network-security concepts. - Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.</td>
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</tr>
<tr>
<td>Content</td>
<td>The course will cover topics spanning four broad themes with a focus on the first two themes: (1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems; (2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks; (3) analysis and inference topics such as traffic monitoring and network forensics; and (4) new technologies related to next-generation networks. In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.</td>
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<tr>
<td>Prerequisites/notice</td>
<td>This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course. The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td>Technics and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Project Management</td>
<td>assessed</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
<td>Customer Orientation</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

268-0101-00L Introduction to Information Security

Only for CAS and DAS in Cyber Security.

Abstract

In this course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students’ understanding of the theory parts. Graduates of the course know the technical foundations of information security and understand the difficulty and complexity involved when trying to build secure systems.

Objective

In this new course, the goal is to introduce the fundamentals of information/cyber security from a technical point of view. Along with theory, hands-on experiments are an important building block of the course and help to deepen the students’ understanding of the theory parts.

268-0102-00L Applied Security Laboratory

Only for DAS in Cyber Security.

Abstract

Hands-on course on applied aspects of information security. Applied information security, operating system security, OS hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.
Objective
The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, logging), application security with an emphasis on web applications (web server setup, common web exploits, authentication, session handling, code security), computer forensics, and risk analysis and risk management.

Content
This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectiveness and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.

Lecture notes
The course is based on the book "Applied Information Security - A Hands-on Approach". More information:
http://www.infsec.ethz.ch/appliedlabbook

Literature
Recommended reading includes:
* Various: OWASP Guide to Building Secure Web Applications, available online
* O'Reilly, Loukides: Unix Power Tools, O'Reilly & Associates.
* Frisch: Essential System Administration, O'Reilly & Associates.
* NIST: Risk Management Guide for Information Technology Systems, available online as PDF
* BSI: IT-Grundschutzhandbuch, available online

Prerequisites / notice
* The lab allows flexible working since there are only few mandatory meetings during the semester.
* The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas: information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.
* Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the recommended requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.
* All participants must sign the lab's charter and usage policy during the introduction lecture.

Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7 credits</td>
<td>2V+2U+2A</td>
<td>D. Basin, M. Ochoa Rondeos</td>
</tr>
</tbody>
</table>

Abstract

Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.

Objective

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems.
Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include:

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature
- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security
Objective
After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.

Content

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>W</th>
<th>Credits</th>
<th>G</th>
<th>S. Matetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>268-0201-00L</td>
<td>Information Security Seminar and Project</td>
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<td></td>
<td>Only for CAS and DAS in Cyber Security.</td>
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<tr>
<td>Objective</td>
<td>Participants of the seminar are assigned a recent topic in cyber security. They are expected to become acquainted with the assigned issue and to prepare a corresponding presentation in the context of the seminar.</td>
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<tr>
<td>Content</td>
<td>Participants have understood and presented a publication or report on a present topic in information security. By attending other participants presentations students get further introduced to additional current information security related topics/incidents.</td>
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<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>W</th>
<th>Credits</th>
<th>G</th>
<th>S. Matetic</th>
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</thead>
<tbody>
<tr>
<td>268-0202-00L</td>
<td>Contemporary Topics in Cyber Security</td>
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<td></td>
<td>Only for CAS and DAS in Cyber Security.</td>
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<tr>
<td>Objective</td>
<td>Students are expected to see behind the curtain of current research and engineering activities related to Cyber Security. At the same time students are introduced to contemporary challenges in cyber security by renowned experts.</td>
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<tr>
<td>Content</td>
<td>The lectures cover contemporary aspects and challenges in Cyber Security. The goal is to present current fields of research/engineering and the latest results. By way of example, Cyber Security Policy is one of sub-modules presented by researchers of the Center for Security Studies at ETH. Besides faculty members of the computer science department, there will be guest lecturers from industry presenting Cyber Security related challenges in their field of activity.</td>
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</tbody>
</table>

Literature
Will be announced during the course.

**DAS in Cyber Security - Key for Type**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
**DAS in Data Science**

**Core Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

**Abstract**
Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

**Objective**
Students master the basic mathematical concepts and algorithms of estimation and machine learning.

**Content**
Review of probability theory;
basics of statistical estimation;
least squares and linear learning;
Hilbert spaces;
singular-value decomposition;
kernel methods, neural networks, and more

**Lecture notes**
Lecture notes will be handed out as the course progresses.

**Prerequisites / notice**
solid basics in linear algebra and probability theory

**Capstone Project**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>266-0100-00L</td>
<td>Capstone Project Only for DAS in Data Science.</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**
The capstone project is part of the DAS in Data Science and is an opportunity to apply the knowledge acquired in the program in an independent, real-world project.

**Objective**
To apply the knowledge acquired in the program in an independent, real-world project.

**Content**
The capstone project can be done under the supervision of the Swiss Data Science Center, or of any core or adjunct faculty of Data Science. The project has to be finished within 6 months. Deadline for a project the following semester conducted at the SDSC is mid June/mid December.

**Specialisation Track**

**Hardware for Machine Learning**

Offered in the Spring Semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0155-00L</td>
<td>Machine Learning on Microcontrollers Registration in this class requires the permission of the instructors. Class size will be limited to 25. Preference is given to students in the MSc EEIT.</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>M. Magno, L. Benini</td>
</tr>
</tbody>
</table>

**Abstract**
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly “smart”. This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the “internet-of-things”, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V)

**Objective**
Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

**Content**
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNn-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

**Image Analysis & Computer Vision**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5902-00L</td>
<td>Computer Vision The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
</tr>
</tbody>
</table>

**Abstract**

**Lecture notes**
Script and exercise sheets. Books will be suggested during the course.

**Prerequisites / notice**
Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

- Prerequisites / notice

#### Neural Information Processing

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0421-00L</td>
<td>Deep Learning in Artificial and Biological Neuronal Networks</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Grewe</td>
</tr>
</tbody>
</table>

**Abstract**

Deep-Learning (DL) is a brain-inspired weak form of AI that allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

**Objective**

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g., simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to ‘error backpropagation’ in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

**Content**

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu</td>
</tr>
</tbody>
</table>

**Abstract**

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended presentation in today’s neuroscience papers.

These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering II</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu</td>
</tr>
</tbody>
</table>

**Abstract**

Understanding of the characteristics of neuromorphic circuit elements.

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

**Prerequisites / notice**

Prerequisites: Background in basics of semiconductor physics helpful, but not required.
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Abstract

Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Content


Lecture notes

A script will be available in English.
System Identification

Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data. To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Closed-loop identification strategies. Trade-off between controller performance and information available for identification.
### Literature


Additional papers will be available via the course Moodle.

### Prerequisites / notice

Control systems (227-0216-00L) or equivalent.

### 252-0535-00L  Advanced Machine Learning  W  10 credits  3V+2U+4A  J. M. Buhmann, C. Cotrini Jimenez

**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- **Fundamentals:**
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- **Supervised learning:**
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- **Unsupervised learning:**
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


**Prerequisites / notice**

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### 252-3005-00L  Natural Language Processing  W  7 credits  3V+3U+1A  R. Cotterell

**Abstract**

This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Objective**

The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

**Content**

This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Literature**

Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

### 263-2400-00L  Reliable and Trustworthy Artificial Intelligence  W  6 credits  2V+2U+1A  M. Vechev

**Abstract**

Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

**Objective**

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.
Content

The course is split into 3 parts:

Robustness in Deep Learning

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

For solving assignments, some programming experience in Python is expected.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and why. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

263-5210-00L Probabilistic Artificial Intelligence W 8 credits 3V+2U+2A A. Krause

Abstract

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit “intelligent” behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.
Content

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice
Solid basic knowledge in statistics, algorithms and programming.
The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Big Data Systems

Number: 252-0834-00L  Title: Information Systems for Engineers  Type: W  ECTS: 4 credits  Hours: 2V+1U  Lecturers: G. Fourny

Abstract

This course provides the basics of relational databases from the perspective of the user.

Objective

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)
The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

263-2800-00L Design of Parallel and High-Performance Computing  W  9 credits  3V+2U+3A  T. Hoefler, M. Püschel

Number of participants limited to 125.

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3010-00L Big Data  W  10 credits  3V+2U+4A  G. Fourny

Abstract
The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.
This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td>Creative Thinking</td>
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<td>Techniques and Technologies</td>
<td>assessed</td>
<td>Decision-making</td>
<td>assessed</td>
<td>Sensitivity to Diversity</td>
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<td>assessed</td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>not assessed</td>
<td>Negotiation</td>
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<td>assessed</td>
<td>not assessed</td>
<td>Communication</td>
<td>not assessed</td>
<td>Critical Thinking</td>
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<tr>
<td>assessed</td>
<td>not assessed</td>
<td>not assessed</td>
<td>not assessed</td>
<td>Integrity and Work Ethics</td>
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</table>

**DAS in Data Science - Key for Type**

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |
### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>ECTS</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td></td>
<td>European Credit Transfer and Accumulation System</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<td>Special students and auditors need special permission from the lecturers.</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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### Diploma Project

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1101-00L</td>
<td><strong>How to Write Scientific Texts</strong></td>
<td>E-</td>
<td>0</td>
<td></td>
<td>U. Koch</td>
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<td></td>
<td>* Strongly recommended prerequisite for Semester Projects and Master Theses at D-ITET (MSc BME, MSc EEIT, MSc EST).</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>- Knowledge on structure and content of scientific texts and presentations</td>
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<td>- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article</td>
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<td>- Discussion of the practice of proper citing and scientific integrity</td>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, &quot;in this paper&quot; paragraph, scientific part, summary, equations, figures)</td>
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<td>* Topic 2: Structure of Scientific Presentations</td>
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<td>* Topic 3: Citation Rules and Citation Software</td>
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<td>* Topic 4: Guidelines for Scientific Integrity</td>
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<td>The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td></td>
<td>ETH &quot;Citation Etiquette&quot;, see <a href="https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html">https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html</a></td>
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<td>ETH &quot;Scientific Integrity&quot;, see <a href="https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html">https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html</a></td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td>Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.</td>
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<tr>
<td>227-3001-00L</td>
<td><strong>Diploma Thesis</strong></td>
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<td>* Only for DAS in Information Technology and Electrical Engineering.</td>
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<td></td>
<td><strong>Registration for the diploma thesis requires the successful completion of 18 credits ECTS from subjects of specialization.</strong></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The Diploma of Advanced Studies finishes with a 3-months diploma thesis which is directed by a professor of the department ITET. Students prove their ability to conduct independent scientific research on a specific research problem, using skills and knowledge acquired during the program. The thesis includes a written report and an oral presentation.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<td>see above</td>
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</table>

### DAS in Information Technology and Electrical Engineering - Key for Type

<table>
<thead>
<tr>
<th>W</th>
<th>Eligible for credits</th>
<th>Dr</th>
<th>Suitable for doctorate</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
**DAS in Military Sciences**

The DAS in Military Sciences programme is executed every second year.

Next start: Autumn Semester 2023.

### DAS in Military Sciences - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
<th>W</th>
<th>Eligible for credits</th>
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</thead>
<tbody>
<tr>
<td>E-</td>
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<td>Eligible for credits and recommended</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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</table>

### Key for Hours

<table>
<thead>
<tr>
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<th>lecture</th>
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<tr>
<td>G</td>
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<tr>
<td>K</td>
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</table>

ECTS European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
## Lectures

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>115-0510-00L</td>
<td>Lecture Week 10: Spatial Development</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>M. Nollert, J. Van Wezemael</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>In this course, the fundamental methods in spatial planning learned in the first week, in particular regarding planning methodology, spatial design and argumentation are consolidated in lectures and case studies.</td>
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<tr>
<td>Objective</td>
<td>The aim of the lecture is the consolidation and the practice of important methodic principles in spatial planning. They provide a basis also for the work in the second Study Project of the MAS program.</td>
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<tr>
<td>115-0511-00L</td>
<td>Lecture Week 11: Urban Planning and Urban Design II</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>S. Kretz, to be announced</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>The second week on urban design and urban planning focuses on a case study in the field of strategic urban design. The course includes lectures, discussions, methodological inputs and a design workshop. Students analyze and discuss a real life problem and elaborate proposals for a suitable urban design strategy.</td>
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<tr>
<td>Objective</td>
<td>The aim of the course is an in-depth understanding of contemporary urban design challenges and an exemplary, case-based experience of elaborating adequate urban design strategies.</td>
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<tr>
<td>115-0512-00L</td>
<td>Lecture Week 12: Spatial Planning: Theory and Methodology</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>A. Voigt</td>
</tr>
<tr>
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<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>Impart thinking patterns and active application of fundamentals of planning theories and methods. The main focus is on plausibility and rigor of reasoning in spatial planning, from problem definition and analysis of its causes to the formulation of robust solutions; development of different planning steps considering communication theory and ethical aspects.</td>
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<tr>
<td>Objective</td>
<td>Autonomous and productive application of analyzed thinking patterns and planning steps; situationally appropriate and task-oriented transfer to new planning problems.</td>
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<tr>
<td>115-0513-00L</td>
<td>Lecture Week 13: Academic Working in Spatial Planning</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>R. Nebel, A. Rupf</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>Understanding what scientific work means in spatial planning. Procedures for clarification processes; basics of scientific working and writing; case studies and exercises.</td>
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<tr>
<td>Objective</td>
<td>Knowledge for a scientific way of working; structuring a scientific paper using the example of the DAS Synopsis or MAS Thesis.</td>
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<tr>
<td>115-0514-00L</td>
<td>Lecture Week 14: Spatial Planning: International Aspects</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>F. Persyn</td>
</tr>
<tr>
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<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td>Abstract</td>
<td>Introduction to international perspectives in spatial planning, exploring various scales and their interconnectedness as well as flows and practices that bridge different cultures of planning. International competitions as a tool to navigate different planning realities, terrains and transformations. Team work on an ongoing case.</td>
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<tr>
<td>Objective</td>
<td>Learning from different spatial planning cultures, their interaction and improving the capacity to understand and bring solutions to diverse planning contexts.</td>
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</tbody>
</table>

### DAS in Spatial Planning - Key for Type

- **E-** Recommended, not eligible for credits
- **O** Compulsory
- **W** Eligible for credits
- **W+** Eligible for credits and recommended
- **Z** Courses outside the curriculum
- **Dr** Suitable for doctorate

### Key for Hours

- **V** lecture
- **G** lecture with exercise
- **U** exercise
- **S** seminar
- **K** colloquium
- **P** practical/laboratory course
- **A** independent project
- **D** diploma thesis
- **R** revision course / private study

### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 607 of 2416
### DAS Preparation for the Swiss Federal Examination in Pharmacy

#### First Series of Courses (Group A)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0810-00L</td>
<td><strong>Gene Technology</strong></td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>K. Eyer, J. Scheuermann</td>
</tr>
</tbody>
</table>
| **Abstract** | The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.  
**Objective** | The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.  
**Content** | I) Genomics and transcriptomics  
Methods and Techniques:  
- Recombinant DNA technology  
- Next generation sequencing methods, sequencing of genomes  
- CRISPR technology  
Application to human biology:  
- Functional genomics/transcriptomics  
- Principles of cancer, genetic diseases  
- Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination  
II) Proteomics  
Methods and Techniques:  
- Protein cloning and expression  
- The antibody molecule  
- Measurement and determination of biomolecular interactions  
- Protein characterization and engineering  
- Modifications and radioactive labelling  
Application to human biology:  
- Protein therapeutics  
- Proteomic approaches for identification of novel disease-related targets and biomarkers  
III) Drug discovery: Protein-based libraries  
- Immune repertoire mining  
- Display and selection technologies  
- Antibody phage display  
- Other polypeptide display technologies  
- Small-molecules display: DNA-encoded chemical libraries  
**Lecture notes** | The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.  
**Fostered competencies** | Subject-specific Competencies: Concepts and Theories, Techniques and Technologies  
Method-specific Competencies: Decision-making, Problem-solving  
Personal Competencies: Creative Thinking, Critical Thinking  
**Literature** | 535-0830-00L | **Pharmaceutical Immunology** | O | 2 credits | 2G | C. Halin Winter, V. Collado Díaz  
**Abstract** | Get Students familiar with basic Immunological concepts of pharmaceutical relevance.  
**Objective** | Get Students familiar with basic Immunological concepts of pharmaceutical relevance.  
**Content** | Chapters 1 - 11 of the Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition; Garland). Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition).  
**Literature** | Paperback  
[www.garlandscience.com]  
535-0421-00L | **Galenic Pharmacy I** | O | 2 credits | 2G | C. Leroux, E. Giger  
**Abstract** | Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharm. excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality and application. Comprehension of molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.  
**Objective** | Knowledge of the most important pharmaceutical excipients, materials, containers, liquid and semi-solid dosage forms, of their production, function, quality, stability and application. Comprehension of the molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.  
**Content** | Introduction and overview of important fundamentals, principles and technologies for the development and manufacturing of dosage forms and drug delivery systems. Overview of the most important pharmaceutical excipients and polymers, their structure, properties and processing; importance of materials properties for containers. Pharmaceutical solvents, fundamentals of solubility and solubilization of drugs. Water treatment processes, sterilization techniques and quality requirements of pharmaceutical water. Parenteral dosage forms and liquid ophthalmics. Surfactants, micelle formation and colloidal systems. Liquid suspensions and emulsions. Stabilization measures in dosage forms.  
**Prerequisites / notice** | Language: German and English
Abstract
The course places the basic pharmaceutical knowledge acquired so far in an applied therapeutic context and fosters interdisciplinary thinking in pharmaceutical sciences. Common pharmaceutical case studies, as they can occur in the professional everyday life of a pharmacist, are worked out in group works, presented and discussed.

Objective
Students
• Are able to analyse, present and discuss common case studies from the pharmacist's practice, based on their basic knowledge in pharmacology.
• are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to undesirable other effects and interactions).
• are able to compare different drugs and derive their therapy-relevant characteristics.

Content
Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:
• Indication
• Dosage Form
• Adverse Drug Reactions
• Interactions
• Contraindications

Lecture notes
Is made available via Moodle.

Literature
As stated in the cases.

Prerequisites / notice
The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and discussed in plenary.

Fostered competencies

Subject-specific Competencies
Concepts and Theories not assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

535-0525-00L Pharmaceutical Cases O 1 credit 1G D. Stämpfli, S. Erni, E. Kut Bacs, P. Obrist

Abstract
This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

Objective
The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

Content
Topics include disease-relevant macroscopic, microscopic, pathobiological and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicology, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

Lecture notes
A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.
Literature

Recommended reading:

Klaus Aktories, Ulrich Förstermann, Franz Hofmann, Klaus Starke.
Allgemeine und spezielle Pharmakologie und Toxikologie.
Urban & Fischer (Elsevier, München)

The classic textbook in Pharmacology:

Goodman and Gilman’s The Pharmacological Basis of Therapeutics
Laurence Brunton, Bjorn Knollman, Randa Hilal-Dandan.
ISBN-10: 1259584739

or 14th Edition (expected Dec. 2022)

Prerequisites / notice

Voraussetzungen: Abschluss Grundstudium

► Second Series of Courses (Group A)

►► Compulsary Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

Objective

Students

- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

Content

"Pharmaceutical Care" und "Health Care";
Häufigste Erkrankungen und Therapien der
- Allergologie
- Angiologie und Hämatologie
- Dermatologie
- Endokrinologie und Diabetologie
- Gastroenterologie
- Infektiologie
- Kardiologie
- Neurologie
- Ophthalmologie
- Otorhinolaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Grundlagen der Chiropraktischen Medizin und Physiotherapie.

Lecture notes

Provided via myStudies.

Literature

As stated in the lecture notes.

Prerequisites / notice

The performance assessments take place on: 20.12.2022 (approx. 11-13h) und 21.12.2022 (approx. 14-16h)

Please note that the assessment of this course must be passed (not compensable).

The performance assessment of the course takes place in two written on campus online partial examinations. The overall grade results from the average of the grades of both partial examinations. If the overall grade is unsatisfactory, both partial examinations must be repeated.

The courses Pharmacology and Toxicology I and II and Pathobiology provide indispensable basics which students must master at the beginning of the semester in order to successfully complete the course.

Pharmacology and Toxicology III must be visited at the same time.

►► Compulsary Courses II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>535-0030-00L</td>
<td>Therapeutic Proteins</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>C. Halin Winter, D. Neri</td>
</tr>
</tbody>
</table>

Abstract

In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

Objective

Students know and understand:
- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 610 of 2416
Objectives:
The course consists of two parts:

In a first part, students will complete their training of pharmaceutical immunology (Chapter 13 - 16 Immunobiology VIII textbook). This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.

The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

Lecture notes
Handouts to the lectures will be available for downloading under http://www.pharma.ethz.ch/scripts/index

Recommended literature
- Janeway’s Immunobiology, by Kenneth Murphy (9th Edition), Chapters 12-16
- Lecture Handouts
- Paper References provided in the Scripts
- EMEA Dossier for Humira

535-0041-00L Pharmacology and Toxicology III

W 2 credits 2G U. Quitterer, M. Arand, Y. Yamauchi

Abstract
The course is divided into two parts. The first part provides a detailed understanding of drugs and the pharmacotherapy of infectious diseases and cancer. The second part gives an overview of the field of pharmacogenomics and toxicogenomics with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

Objective
The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases and cancer. The course also provides an overview of the field of pharmacogenomics and toxicogenomics, with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

Content
Topics include the pharmacology and pharmacotherapy of infectious diseases and cancer. In the field of pharmacogenomics and toxicogenomics, the course is focused on genetics, genome-wide association studies, examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development.

Lecture notes
A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.

Literature
Recommended reading:
ISBN-10: 1259584739
or 14th edition (expected Oct. 2022)
or
Urban & Fischer (Elsevier, München)

535-0050-00L Pharmacoepidemiology and Drug Safety

W 3 credits 2G A. Burden, S. Russmann

Abstract
Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.

Objective
Objectives:
- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for the quantitative evaluation of drug safety
- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

Content
- Historical landmarks of drug safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)
- Medication errors, clinical pharmacology / clinical pharmacy
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, ‘Big Data’
- Interactive discussion of many real-life examples for each topic

Lecture notes
This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through seminars, case studies in small groups.

Reading material and scripts will be provided for each week.

Literature
Recommended literature:
- Rothman: Introduction to Epidemiology
- Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
- Gigerenzer: Risk Savvy - How to Make Good Decisions

535-0137-00L Clinical Chemistry II

W 1 credit 1V M. Hersberger

Abstract
Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Objective
Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interpret selected tests.

Content
Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Lecture notes
Documentation will be available before the lectures electronically.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 611 of 2416
Literature
- Jürgen Hallbach, Klinische Chemie und Hämatologie für den Einstieg, Thieme Verlag
- Harald Renz, Praktische Labordiagnostik, de Gruyter Verlag
- Walter Guder, Das Laborbuch für Klinik und Praxis, Elsevier Verlag
- Lothar Thomas, Labor und Diagnose, TH Books
- William Marshall, Clinical Chemistry, Mosby Ltd.
- Alan H.B. Wu, Tietz, Clinical Guide to Laboratory Tests, Saunders

Prerequisites / notice
Requirement: basic knowledge in clinical chemistry and laboratory diagnostics

► Second Series of Courses (Group B)

<table>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</table>

Abstract
This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

Objective
Students

- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

Content
"Pharmaceutical Care" und "Health Care";
Häufigste Erkrankungen und Therapien der
- Allergologie
- Angiologie und Hämatologie
- Dermatologie
- Endokrinologie und Diabetologie
- Gastroenterologie
- Infektiologie
- Kardiologie
- Neurologie
- Ophthalmologie
- Otorhinolaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Grundlagen der Chiropraktischen Medizin und Physiotherapie.

Lecture notes
Provided via myStudies.

Literature
As stated in the lecture notes.

Prerequisites / notice
The performance assessments take place on: 20.12.2022 (approx. 11-13h) und 21.12.2022 (approx. 14-16h)

Please note that the assessment of this course must be passed (not compensable).

The performance assessment of the course takes place in two written on campus online partial examinations. The overall grade results from the average of the grades of both partial examinations. If the overall grade is unsatisfactory, both partial examinations must be repeated.

The courses Pharmacology and Toxicology I and II and Pathobiology provide indispensable basics which students must master at the beginning of the semester in order to successfully complete the course.

Pharmacology and Toxicology III must be visited at the same time.

535-0137-00L Clinical Chemistry II O 1 credit 1V M. Hersberger

Abstract
Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Objective
Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interpret selected tests.

Content
Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

Lecture notes
Documentation will be available before the lectures electronically.

Literature
- Jürgen Hallbach, Klinische Chemie und Hämatologie für den Einstieg, Thieme Verlag
- Harald Renz, Praktische Labordiagnostik, de Gruyter Verlag
- Walter Guder, Das Laborbuch für Klinik und Praxis, Elsevier Verlag
- Lothar Thomas, Labor und Diagnose, TH Books
- William Marshall, Clinical Chemistry, Mosby Ltd.
- Alan H.B. Wu, Tietz, Clinical Guide to Laboratory Tests, Saunders

Prerequisites / notice
Requirement: basic knowledge in clinical chemistry and laboratory diagnostics

► Third Series of Courses (Group A and B)

★★ Practical Pharmacy I and Compensatory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 612 of 2416
This course provides basic knowledge relevant to pharmacy and its application in nephrology, phytotherapy, complementary medicine, wound care and pharmaceutical care.

Students know and understand the therapeutic concepts of the mentioned topics and their application in practice.

(for detailed learning objectives see the guidelines)

- know the concept of continuum of care and its practical implementation. They know the medication process within and after hospitalization.
- know the therapeutic guidelines, drug classes and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

Lecture notes
Provided via myStudies.

Literature
As specified in the lecture notes


This course provides basic clinical and pharmaceutical knowledge and its application for triage, diagnostics and therapy support for the most common diseases in geriatrics, women's health, oncology, paediatrics and neurology (epilepsy). In addition, the role of nutrition in special life situations and in selected health disorders is taught.

Objective
- know and understand the pathomechanisms and the clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed.
- can triage patients by applying this knowledge: i.e. analyse simple symptoms and disease patterns, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, drug classes and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

Lecture notes
Provided via myStudies.

Literature
As specified in the lecture notes

★★ Practical Pharmacy II

Number Title Type ECTS Hours Lecturers
535-5524-00L Clinical Trainings ■ O 2 credits 3G A. Gutzeit, D. Stämpfli, P. Wiedemeier

Basic training on and around patients with practical confrontation. The path of acute patients from patient presentation, through triage and diagnostics to therapy.

Objective
Students will be able to understand the medical-clinical way of thinking for the diagnosis and treatment of acute patients. They complete the change of perspective from the molecular mechanism of action of drugs to the treatment of patients in all its complexity. Using real patient examples, students acquire exemplary knowledge in diagnostics and triage as well as therapy selection and therapy support. They consolidate their understanding of the importance of pharmaceutical care before and after hospitalization.

Content

535-5502-00L Pharmaceutical Manufacturing in Small Quantities (Compounding) ■ O 3 credits 5G P. G. Tiefenböck, A. Romagna

Pharmaceutical Manufacturing relevant for the community pharmacy considering the "GMP-Regeln in kleinen Mengen" of the Pharmacopoeia. The preparation of extemporaneous products covering the most common forms under consideration of their Risks and Quality Assurance.

Objective
The students are able to produce pharmaceutical relevant drug Systems without further assistance, leges artis, applying the right techniques and material. The production and packaging has to follow GMP rules and tailored for the patients need. The quality control and correct documentation have to be followed. The students know the most relevant specifications, concentration and dosing ranges of common APIs and excipients. The students are familiar with the relevant literature (Pharmaceutical and legal basis) regarding the Pharmaceutical manufacturing relevant for the community pharmacies.

Content
Vermittlung der wichtigsten Kenntnisse, Arbeitsschnitte und -techniken im Bereich der Arzneimittelherstellung in kleinen Mengen (Formula) mit Fokus auf der Herstellung, Qualitätssicherung und Risikobeurteilung einschliesslich der patientenspezifischen Abgabepraxis.

In den Praktika: Anhand praxis-relevanter Beispiele wird die Aufgabenplanung, die Fertigung einschliesslich die korrekte Verwendung der Gerätschaften, die Inprozesskontrolle, die Verpackung und die Qualitätssicherung diverser Rezepte und Arzneiformen geübt. Unter Einbezug risikoadaptierter Massnahmen erfolgt die Qualitätssicherung, -kontrolle und Einhaltung von Hygieneregeln incl. Rezepturverifikation und sachgerechter Dokumentation.

Prerequisites / notice
Safety concept: https://chab.ethz.ch/studium/bachelor1.html

535-5503-00L Institutional Pharmacy ■ O 2 credits 3G P. Wiedemeier, M. Lutters, E. Martinelli, I. S. Vogel Kahmann

Organisation of institutional environments (emergency hospitals), with special focus on the medication process and institutional pharmaceutical care (continuum of care).

Objective
Students understand the concept of continuum of care and its practical implementation. They know the medication process within an institutional environment. They are able to find the necessary information and deal with problems in connection with pharmaceuticals, to evaluate them and to communicate and documentate their findings adequately. They know how a hospital is organised (procedures, possible problems), responsibilities of the different members of the staff and, most importantly, what the function of a hospital pharmacy is.
Principals of the organisation of institutional environments (emergency hospitals), with special focus on medication processes and institutional pharmaceutical care (circulation of medication, continuum of care). Hygiene regulations, medical products, applications, drug formularies, patient files, SOAP notes, kardex study. Participation at interdisciplinary visits, internal trainings and doctors’ reports as well as visitation of the emergency room. Drug interaction, generic substitution, quality management and pharmacovigilance.

535-5526-00L Injection Techniques and Vaccinations O 2 credits 3G I. S. Vogel Kahmann, C. Halin Winter

Abstract

Die Studierenden erlernen die praktische Durchführung von subkutanen (s.c.) und intramuskulären (i.m.) Injektionen. Sie wissen, wie in Notfallsituationen vorzugehen ist. Die Besonderheiten von häufig eingesetzten parenteral zu verabreichenden Medikamenten, insbesondere von Impfungen, sind bekannt.

Objective

Die Studierenden erwerben das theoretische Wissen und die praktischen Fähigkeiten, welche für die s.c. und i.m. Verabreichung von Medikamenten erforderlich sind. Sie sind fähig, Risikopatienten zu identifizieren und sind geschult, bei Notfällen (z.B. Anaphylaxie) korrekt zu handeln. Die Studierenden kennen die in der Schweiz zur Verfügung stehenden Impfungen, den schweizerischen Impfplan und sind vertraut mit der Anwendung von elektronischen Hilfsmitteln bei Fragestellungen rund um das Impfen. Die Studierenden kennen die rechtlichen Grundlagen und regulatorischen Aspekte bezüglich Impfen in der Apotheke. Die Studierenden kennen verschiedene Verbandmaterialien und können diese anwenden, um akute Wunden zu versorgen.

Content

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Content


Lecture notes

Wird auf mystudies veröffentlicht.

Literature

Wird im Skript angegeben.

Prerequisites / notice


Schutzkonzept: https://chab.ethz.ch/studium/bachelor1.html

DAS Preparation for the Swiss Federal Examination in Pharmacy - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
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<tr>
<td>E</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
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<td>W</td>
<td>Eligible for credits</td>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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Key for Hours

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<tr>
<th>V</th>
<th>lecture</th>
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<tr>
<td>G</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
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<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Advanced Machine Learning

**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


**Prerequisites / notice**

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Neural Network Theory

**Abstract**

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

**Objective**

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

**Lecture notes**

Detailed lecture notes are available on the course web page [https://www.mins.ee.ethz.ch/teaching/int/](https://www.mins.ee.ethz.ch/teaching/int/)

**Prerequisites / notice**

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

Fundamentals of Mathematical Statistics

**Abstract**

Does not take place this semester.

**Objective**

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
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7. VC dimension of neural networks
8. Generalization error in neural network learning

**Lecture notes**

Detailed lecture notes are available on the course web page [https://www.mins.ee.ethz.ch/teaching/int/](https://www.mins.ee.ethz.ch/teaching/int/)
### Data Management

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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>A. Steger</td>
</tr>
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</table>

**Abstract**

Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

**Objective**

After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**

Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Lecture notes**

Yes.

**Literature**


| 263-3010-00L | Big Data                                                                 | W    | 10 credits | 3V+2U+4A | G. Fourny          |

**Abstract**

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

**Objective**

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

**Content**

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSON, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

**Literature**

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 616 of 2416
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we cover the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.
Content

1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content
The entropy rate of a source. Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

227-0689-00L System Identification W 4 credits 2V+1U R. Smith

Abstract
Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.

Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models. Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.


Literature
Additional papers will be available via the course Moodle.

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.

227-2210-00L Computer Architecture W 8 credits 6G+1A O. Mutlu

Abstract
Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

Objective
We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

Content
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

Lecture notes
All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture

The video recordings of the lectures are expected to be made available after lectures.

See the course website for detailed and complete content of past incarnations of the course: https://safari.ethz.ch/architecture

Literature
See https://safari.ethz.ch/architecture for past examples.

We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

Prerequisites / notice

252-1414-00L System Security W 7 credits 2V+2U+2A S. Capkun, S. Shinde

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

### Objective

Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

### Content

The course is split into 3 parts:

- Robustness in Deep Learning
- Privacy of Machine Learning
- Fairness of Machine Learning

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

### Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

### Method-specific Competencies
- Analytical Competencies assessed
- Problem-solving assessed

### Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

### Prerequisites / notice

Number of participants limited to 125.

**Objective**
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Content**
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice**
This course is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

### 263-5005-00L Artificial Intelligence in Education

**W 3 credits 1V+0.5U+M. Sachan, T. Sinha**

**Abstract**
Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on project sets and projects to solve problems in education with the help of AI.

**Objective**
The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.

**Content**
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

**Lecture notes**
Lecture slides will be made available at the course Web site.

**Literature**
No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

**Prerequisites / notice**
There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

### 263-5210-00L Probabilistic Artificial Intelligence

**W 8 credits 3V+2U+2A A. Krause**

**Abstract**
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.
Objective: How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content: Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice: Solid basic knowledge in statistics, algorithms and programming. The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

263-5255-00L Foundations of Reinforcement Learning

Does not take place this semester.

W 5 credits 2V+2A N. He

Number of participants limited to 190.

Abstract: Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M-S. students with strong research interests in reinforcement learning, optimization, and control.

Objective: This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to:
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover "new" applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content: Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes: Lecture notes will be posted on Moodle.

Literature: Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas


Algorithms for Reinforcement Learning, Csaba Czempegvari.


Prerequisites / notice: Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5300-00L Guarantees for Machine Learning

W 7 credits 3V+1U+2A F. Yang, A. Sanyal

Number of participants limited to 30.

Abstract: This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective: By the end of the semester students should be able to:
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content: This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:
- how overparameterized models generalize (statistically and computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice: Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)
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<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Methodspecific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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| 263-5902-00L Computer Vision | W 8 credits 3V+1U+3A M. Pollefeys, S. Tang, F. Yu | Objective The objectives of this course are: 1. To introduce the fundamental problems of computer vision. 2. To introduce the main concepts and techniques used to solve these. 3. To enable participants to implement solutions for reasonably complex problems. 4. To enable participants to make sense of the computer vision literature. 
| Content Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition. | Prerequisites / notice It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course. |
| 401-0625-01L Applied Analysis of Variance and Experimental Design | W 5 credits 2V+1U L. Meier | Objective Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R. 
| Content Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power. | Prerequisites / notice The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held. |
| 401-3054-14L Probabilistic Methods in Combinatorics | W 6 credits 2V+1U B. Sudakov | Objective The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness. 
| Content Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power. | Literature G. Oehlerl: A First Course in Design and Analysis of Experiments, W.H. Freeman and Company, New York, 2000. |
| 401-3055-64L Algebraic Methods in Combinatorics | W 6 credits 2V+1U B. Sudakov | Objective The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand proof techniques and to use them autonomously on related problems. 
| Content Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. | Literature - The Probabilistic Method, by N. Alon and J. H. Spencer, 3rd Edition, Wiley, 2008. 
- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002. |
| 401-3601-00L Probability Theory | W 10 credits 4V+1U W. Werner, D. Schröder | Objective Does not take place this semester. 
| Content At most one of the three course units (Bachelor Core Courses) 401-3461-00L Functional Analysis I 401-3531-00L Differential Geometry I 401-3601-00L Probability Theory can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change. | Lecture notes The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757 
Prerequisites / notice Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely. Students are expected to have a mathematical background and should be able to write rigorous proofs. |
Abstract
Basics of probability theory and the theory of stochastic processes in discrete time

Objective
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes
will be available in electronic form.

Literature
H. Bauer, Probability Theory, de Gruyter 1996
J. Jacod and P. Protter, Probability essentials, Springer 2004
A. Klenke, Wahrscheinlichkeitstheorie, Springer 2006
D. Williams, Probability with martingales, Cambridge University Press 1991

401-3612-00L  
Stochastic Simulation  
W  
5 credits  
2V+1U  
F. Sigrist

Abstract
This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

Objective
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Content
Examples of simulations in different fields (computer science, statistics, statistical mechanics, operations research, financial mathematics).
Generation of uniform random variables.

Lecture notes
A script will be available in English.

Literature

Prerequisites / notice
Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

401-3642-00L  
Brownian Motion and Stochastic Calculus  
W  
5 credits  
2V+1U  
F. Sigrist

Abstract
Moreover, 401-3601-00L Probability Theory can only be recognised for the Bachelor Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Objective
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes
will be available in electronic form.

Literature
H. Bauer, Probability Theory, de Gruyter 1996
J. Jacod and P. Protter, Probability essentials, Springer 2004
A. Klenke, Wahrscheinlichkeitstheorie, Springer 2006
D. Williams, Probability with martingales, Cambridge University Press 1991

Prerequisites / notice
Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

401-3622-00L  
Statistical Modelling  
W  
8 credits  
4G  
P. L. Böhlmann

Abstract
In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

Objective
Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

Content

Prerequisites / notice
This is the course unit with former course title “Regression”. Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

401-3627-00L  
High-Dimensional Statistics  
W  
4 credits  
2V  
P. L. Böhlmann

Abstract
Does not take place this semester.

Objective
“High-Dimensional Statistics” deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Content
Knowledge of methods and basic theory for high-dimensional statistical inference

Literature

Prerequisites / notice
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

401-3901-00L  
Linear & Combinatorial Optimization  
W  
11 credits  
4V+2U  
R. Zenklusen

Abstract
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Objective

The goal of this course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Literature


Prerequisites / notice

Solid background in linear algebra.

Fostered competencies

- Former course title: Mathematical Optimization.
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

- Method-specific Competencies
  - Stationarity
  - Autocorrelation
  - Trend estimation
  - Elimination of seasonality
  - Spectral analysis, spectral densities
  - Forecasting
  - ARMA, ARIMA, Introduction into GARCH models

- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation

- Personal Competencies
  - Adaptability and Flexibility
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

- Technical Competencies
  - Solid background in linear algebra.

- Analytical Competencies
  - Most self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

- Method-specific Competencies
  - Introduction to various mathematical aspects of Data Science.
  - These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

- Lecture notes
  - The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity–including abstract thinking and the ability to understand and write proofs.

- Social Competencies
  - We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.
  - A. Bandeira and H. Bölcskei

- Former course title: Mathematical Optimization.

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
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- Method-specific Competencies
  - Stationarity
  - Autocorrelation
  - Trend estimation
  - Elimination of seasonality
  - Spectral analysis, spectral densities
  - Forecasting
  - ARMA, ARIMA, Introduction into GARCH models

- Social Competencies
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  - Cooperation and Teamwork
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- Personal Competencies
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  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

- Technical Competencies
  - Solid background in linear algebra.

- Analytical Competencies
  - Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

- Method-specific Competencies
  - Introduction to various mathematical aspects of Data Science.
  - These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

- Lecture notes
  - The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity–including abstract thinking and the ability to understand and write proofs.

- Social Competencies
  - We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.
  - A. Bandeira and H. Bölcskei
Abstract
The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.

Objective
By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.

Content
Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

Lecture notes
Distributed via moodle.

Literature
Nielsen and Chuang, Quantum Information and Computation
Preskill, Lecture Notes on Quantum Computation
Wilde, Quantum Information Theory
Watrous, The Theory of Quantum Information

Interdisciplinary Electives

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>227-0945-00L</td>
<td>Cell and Molecular Biology for Engineers I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>to be announced</td>
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Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

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<tr>
<td>261-5112-00L</td>
<td>Algorithms and Data Structures for Population Scale</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>A. Kahles</td>
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<td>Genomics</td>
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<td>Number of participants limited to 30.</td>
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Abstract
Research in Biology and Medicine have been transformed into disciplines of applied data science over the past years. Not only size and inherent complexity of the data but also requirements on data privacy and complexity of search and access pose a wealth of new research questions.

Objective
This interactive course will explore the latest research on algorithms and data structures for population scale genomics applications and give insights into both the technical basis as well as the domain questions motivating it.

Content
Over the duration of the semester, the course will cover three main topics. Each of the topics will consist of 70-80% lecture content and 20-30% seminar content.
1) Algorithms and data structures for text and graph compression. Motivated through applications in compressive genomics, the course will cover succinct indexing schemes for strings, trees and general graphs, compression schemes for binary matrices as well as the efficient representation of haplotypes and genomic variants.
2) Stochastic data structures and algorithms for approximate representation of strings and graphs as well as sets in general. This includes winnowing schemes and minimizers, sketching techniques, (minimal perfect) hashing and approximate membership query data structures.
3) Data structures supporting encryption and data privacy. As an extension to data structures discussed in the earlier topics, this will include secure indexing using homomorphic encryption as well as design for secure storage and distribution of data.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0017-00L</td>
<td>Computational Biology</td>
<td>W</td>
<td>6</td>
<td>3G+2A</td>
<td>T. Vaughan, C. Magnus, T. Stadler</td>
</tr>
</tbody>
</table>

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics
Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

The course will cover advanced topics in Internet routing and forwarding such as:
- Fast Convergence
- Quality of Service/Queuing/Scheduling
- Traffic Engineering and Load Balancing
- Tunneling
- Network virtualization
- Network programmability (OpenFlow, P4)
- Network measurements

The course will be divided in two main blocks. The first block (~8 weeks) will interleave classical lectures with practical exercises and labs. The second block (~6 weeks) will consist of a practical project which will be performed in small groups (~3 students). During the second block, lecture slots will be replaced by feedback sessions where students will be able to ask questions and get feedback about their project. The last week of the semester will be dedicated to student presentations and demonstrations.

Lecture notes
Lecture slides will be available on moodle.

Literature
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

<table>
<thead>
<tr>
<th>252-1411-00L</th>
<th>Security of Wireless Networks</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U+2A</th>
<th>S. Capkun, K. Kostiainen</th>
</tr>
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<tbody>
<tr>
<td>Objective</td>
<td>After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.</td>
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<table>
<thead>
<tr>
<th>227-0575-00L</th>
<th>Advanced Topics in Communication Networks</th>
<th>W</th>
<th>6 credits</th>
<th>2V+2U</th>
<th>L. Vanbever, R. Jacob</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover advanced topics in Internet routing and forwarding.</td>
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<td>Objective</td>
<td>The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be &quot;hands-on&quot; and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.</td>
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<tr>
<td>Content</td>
<td>The course will cover advanced topics in Internet routing and forwarding such as:</td>
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<td></td>
<td>- Tunneling</td>
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<tr>
<td></td>
<td>- Hierarchical routing</td>
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<tr>
<td></td>
<td>- Traffic Engineering and Load Balancing</td>
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<tr>
<td></td>
<td>- Virtual Private Networks</td>
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<tr>
<td></td>
<td>- Quality of Service/Queueing/Scheduling</td>
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<td>- Fast Convergence</td>
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<td>- Network virtualization</td>
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<td>- Network programmability (OpenFlow, P4)</td>
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<td>- Network measurements</td>
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The course will be divided in two main blocks. The first block (~8 weeks) will interleave classical lectures with practical exercises and labs. The second block (~6 weeks) will consist of a practical project which will be performed in small groups (~3 students). During the second block, lecture slots will be replaced by feedback sessions where students will be able to ask questions and get feedback about their project. The last week of the semester will be dedicated to student presentations and demonstrations.

Lecture notes
Lecture notes and material will be made available before each course on the course website.

Literature
Relevant references will be made available through the course website.

Prerequisites / notice
Prerequisites: Communication Networks (227-0120-00L) or equivalents / good programming skills (in any language) are expected as both the exercises and the final project will involve coding.

<table>
<thead>
<tr>
<th>263-4640-00L</th>
<th>Network Security</th>
<th>W</th>
<th>8 credits</th>
<th>2V+2U+3A</th>
<th>A. Perrig, S. Frei, M. Legner, K. Paterson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
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<td>Content</td>
<td>Attendees will apply these concepts to a number of applications yielding biological insight into:</td>
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<td>The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation &amp; extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.</td>
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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</tbody>
</table>
Mathematical Foundations for Finance

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This course is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course. The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Life Insurance Mathematics

Objective
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Prerequisites / notice
- Black-Scholes formula
- stochastic calculus: Itô’s formula, Girsanov transformation, Itô’s representation theorem
- stochastic integration
- valuation and hedging in complete markets
- absence of arbitrage and martingale measures
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô’s formula, Girsanov transformation, Itô’s representation theorem
- Black-Scholes formula

Content
Topics to be covered include:
- financial market models in finite discrete time
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô’s formula, Girsanov transformation, Itô’s representation theorem
- Black-Scholes formula

Lecture notes
See information on course homepage

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: not assessed
- Techniques and Technologies: not assessed
- Analytical Competencies: not assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Method-specific Competencies
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

401-3913-01L Mathematical Foundations for Finance

Objective
First introduction to main modelling ideas and mathematical tools from mathematical finance

Content
Topics to be covered include:
- financial market models in finite discrete time
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô’s formula, Girsanov transformation, Itô’s representation theorem
- Black-Scholes formula

Lecture notes
See information on course homepage

Prerequisites / notice
Prerequisites: Results and facts from probability theory as in the book “Probability Essentials” by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course “Wahrscheinlichkeitslehre”.)

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Method-specific Competencies
- Project Management: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

401-3922-00L Life Insurance Mathematics

Abstract
The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.
The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

The following topics are treated:
- Collective Risk Modeling
- Individual Claim Size Modeling
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tariffication
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, experience and exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds

This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

Prerequisites / notice
This course does not take place this semester.

401-3925-00L
Non-Life Insurance: Mathematics and Statistics

Abstract
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, experience and exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Objective
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Content
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Lecture notes
An excerpt of last year's lecture notes is available here: https://sites.google.com/site/philipparbenz/reinsuranceanalytics

Prerequisites / notice
Basic knowledge in statistics, probability theory, and actuarial techniques
### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

### Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

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#### 261-5111-00L Asset Management: Advanced Investments
- (University of Zurich)
- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- UZH Module Code: MFOEC207

**Abstract**
Comprehension and application of advanced portfolio theory

**Objective**
Comprehension and application of advanced portfolio theory

**Content**
The theoretical part of the lecture consists of the topics listed below.

- Standard Markowitz Model and Extensions
- MV Optimization, MV with Liabilities and CAPM.
- The Crux with MV
- Resampling, regression, Black-Litterman, Bayesian, shrinkage, constrained and robust optimization.
- Downside and Coherent Risk Measures
- Definition of risk measures, MV optimization under VaR and ES constraints.
- Risk Budgeting
- Equal risk contribution, most diversified portfolio and other concentration indices
- Regime Switching and Asset Allocation
- An introduction to regime switching models and its intuition.
- Strategic Asset Allocation
- Introducing a continuous-time framework, solving the HJB equation and the classical Merton problem.

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#### 401-8905-00L Financial Engineering (University of Zurich)
- Does not take place this semester.
- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- UZH Module Code: MFOEC200

**Abstract**
This lecture is intended for students who would like to learn more on equity derivatives modelling and pricing.

**Objective**
Quantitative models for European option pricing (including stochastic volatility and jump models), volatility and variance derivatives, American and exotic options.

**Content**
After introducing fundamental concepts of mathematical finance including no-arbitrage, portfolio replication and risk-neutral measure, we will present the main models that can be used for pricing and hedging European options e.g. Black-Scholes model, stochastic and jump-diffusion models, and highlight their assumptions and limitations. We will cover several types of derivatives such as European and American options, Barrier options and Variance-Swaps. Basic knowledge in probability theory and stochastic calculus is required. Besides attending class, we strongly encourage students to stay informed on financial matters, especially by reading daily financial newspapers such as the Financial Times or the Wall Street Journal.

**Lecture notes**
Script.

**Prerequisites / notice**
Basic knowledge of probability theory and stochastic calculus. Asset Pricing.
Abstract
Advanced course on mathematical finance:
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- additional topics

Objective
Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes).

Content
This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- and probably others

Lecture notes
The course is based on different parts from different books as well as on original research literature.

Lecture notes will not be available.

Prerequisites / notice
Prerequisites are the standard courses
- Probability Theory (for which lecture notes are available)
- Brownian Motion and Stochastic Calculus (for which lecture notes are available)
Those students who already attended "Introduction to Mathematical Finance" will have an advantage in terms of ideas and concepts.

This course is the second of a sequence of two courses on mathematical finance. The first course "Introduction to Mathematical Finance" (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imsf/education/education-in-stochastic-finance/overview-of-courses.html.

103-0227-00L Application Development in Cartography W 6 credits 4G L. Hurni

Abstract
This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Objective
Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.

Content
- 3D cartography
- Web mapping
- Data processing
- Animations and interactions
- Map and UI design
- Web application development
- Programming (JavaScript)

Lecture notes
Handouts of the lectures and exercise documents are available on Moodle.

Prerequisites / notice
Prerequisites are the standard courses
- Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

Fostered competencies
Subject-specific Competencies
- Techniques and Technologies assessed
- Analytical Competencies assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

Method-specific Competencies
- Creative Thinking assessed
- Critical Thinking assessed
- Self-direction and Self-management assessed

Social Competencies
- Cooperation and Teamwork assessed

Personal Competencies
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management assessed

103-0717-00L Geoinformation Technologies and Analysis W 6 credits 5G M. Raubal

Abstract
Geoinformationstechnologien und -analysen für Fortgeschrittene: Mobile GIS; Web-GIS & Geo-Web-Services; Spatial Big Data; Zeitliche Aspekte in GIS; Analyse von Bewegungsdaten; Benutzerschnittstellen

Objective

Content
- Mobile GIS
- Web-GIS & Geo-Web-Services
- Spatial Big Data
- Zeitliche Aspekte in GIS
- Analyse von Bewegungsdaten
- Benutzerschnittstellen

Lecture notes
Vorlesung und Präsentationen werden digital zur Verfügung gestellt.

Prerequisites / notice
GIS GZ

Literature
The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods. Students will learn how to work with novel geoinformation technologies such as virtual/mixed reality or mobile applications. They will engage in teamwork, application design, programming and presenting their results.

This lab focuses on presenting spatial, temporal, and open data in tangible ways. Students will learn how to work with novel geoinformation technologies force us to think carefully about notions of fairness and justice and how they should be applied. We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

This series is a joint project by ETH Zurich and the Universities of St. Gallen and Zurich. It provides an overview of interdisciplinary research on intellectual property, innovation, antitrust, privacy & technology policy. Scholars from law, economics, management and related fields present their current research. All speakers are internationally well-known experts from Europe, the U.S. & beyond. The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Critical Thinking
Problem-solving

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.
Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe transport planning methods.

- **Objective**: Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

- **Content**: The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:
  * Empirical Research and Network Data
  * Macro and Micro Structure
  * Centrality
  * Roles
  * Cohesion

- **Lecture notes**: Lecture notes are distributed via the associated course moodle.

- **Literature**:

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**851-0252-13L**

Network Modeling

- **Prerequisites / notice**: Students are required to have basic knowledge in inferential statistics, such as regression models.

- **Abstract**: Network science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

- **Objective**: Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and tests those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and develop an understanding of how those can be fit to empirical data. This will enable students to independently address research questions from various social science fields. They will be able to assess the appropriateness of approaches for topics such as privacy and information spread on a variety of platforms. Students will be able to develop and evaluate methods that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

- **Content**: The following topics will be covered:
  - Introduction to network models and their applications
  - Stylized models:
    * uniform random graph models
    * small world models
    * preferential attachment models
  - Models for testing hypotheses while controlling for the network structure:
    * Quadratic assignment procedure regression (QAP regression)
    * Models for testing hypotheses on the network structure:
      * Models for one single observation of a network: exponential random graph models (ERGMs)
      * Models for panel network data: stochastic actor-oriented models (SAOMs)
      * Models for relational event data: dynamic network actor models (DynAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

- **Lecture notes**: Slides and lecture notes are distributed via the associated course moodle.

- **Literature**:

- **Prerequisites / notice**: Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

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**851-0586-03L**

Applied Network Science: Social Media Networks

- **Prerequisites / notice**: Number of participant limited to 20

- **Abstract**: We study applications of network science methods, this semester in the domain of social media. Topics are selected for diversity in research questions and techniques for topics such as privacy and information spread on a variety of platforms. Student teams present results from the recent literature, possibly with replication, in a one-day conference. By examples from recent research on social media, students learn to appreciate that and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

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**101-0417-00L**

Transport Planning Methods

- **Prerequisites / notice**: Background in basics of semiconductor physics helpful, but not required.
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Objectives
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

Content
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Literature

101-0491-00L

Agent Based Modeling in Transportation

W 6 credits 4G M. Balac

Abstract
This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models' current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

Objective
- At the end of the course, the students should:
  - have an understanding of agent-based modeling
  - have an understanding of MATSim
  - have an understanding of the process needed to set up an agent-based study
  - have practical experience of using MATSim to perform practical transportation studies

Content
This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.
Here the open-source eqasim framework used at ETH Zurich to set up agent-based models will be introduced
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

Literature
Agent-based modeling in general
MATSim

Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

Prerequisites / notice
There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.
Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

701-0023-00L

Atmosphere

W 3 credits 2V E. Fischer, T. Peter

Abstract
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Objective
- Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Content
- Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Lecture notes
Written information will be supplied.

Literature

701-0473-00L

Weather Systems

W 3 credits 2G M. A. Sprenger, F. Scholder-Aemessger

Abstract
Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes
Atmospheric Science, An Introductory Survey
Lecture notes and slides

In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover

- Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situtations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes

Prerequisites / notice
Basic physics

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### Data Science Lab

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>263-3300-00L</td>
<td>Data Science Lab</td>
<td>O</td>
<td>14</td>
<td>9P</td>
<td>C. Zhang, V. Boeva, R. Cotterell, A. Ilic, J. Vogt, F. Yang</td>
</tr>
</tbody>
</table>

**Abstract**

In this class, we bring together data science applications provided by ETH researchers outside computer science and teams of computer science master's students. Two to three students will form a team working on data science/machine learning-related research topics provided by scientists in a diverse range of domains such as astronomy, biology, social sciences etc.

**Objective**

The goal of this class is for students to gain experience of dealing with data science and machine learning applications "in the wild". Students are expected to go through the full process starting from data cleaning, modeling, execution, debugging, error analysis, and quality/performance refinement.

Prerequisites / notice
At least 8 KP must be obtained under Data Analysis and at least 8 KP must be obtained under Data Management and Processing.

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### Seminar

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-5051-00L</td>
<td>Advanced Topics in Machine Learning</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>J. M. Buhmann, R. Cotterell, N. He, F. Yang, M. Elassady</td>
</tr>
</tbody>
</table>

**Abstract**

In this seminar, recent papers of the pattern recognition and machine learning literature are presented and discussed. Possible topics cover statistical models in computer vision, graphical models and machine learning.

**Objective**

The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.

**Content**

The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from learning-related research topics provided by scientists in social sciences etc.

**Literature**

The papers will be presented in the first session of the seminar.

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<table>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>263-3504-00L</td>
<td>Hardware Acceleration for Data Processing</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>G. Alonso</td>
</tr>
</tbody>
</table>

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**Literature**

The papers will be presented in the first session of the seminar.
Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, 

The goal of the seminar is not only to familiarize students with exciting new research topics, but also to teach basic scientific writing and 

Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the 

Communication

Student Seminar in Statistics: Inference in Some Non-

This seminar discusses recent relevant contributions to the fields of medical machine learning and related areas. Each participant will hold 

Topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to 

will officially fail the seminar.

Abstract

The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, 

Objective

The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, 

Content

The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, 

Prerequisites / notice

Fostered competencies

Method-specific Competencies

Social Competencies

Personal Competencies

Analytical Competencies

Communication

Critical Thinking

assessed

assessed

assessed

Number of participants limited to 24.

Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have

Abstract

This seminar is an introduction to different machine learning algorithms, and their applications in medical and biological fields.

Objective

The objective of the seminar is to provide an overview of key machine learning algorithms and their applications in medical and biological fields.

Content

The seminar will cover topics such as supervised and unsupervised learning, including but not limited to logistic regression, support vector machines, and clustering algorithms.

Prerequisites / notice

Students taking this seminar should have a foundational understanding of probability theory, linear algebra, and programming basics.

401-3620-20L

Student Seminar in Statistics: Inference in Some Non-Standard Regression Problems

Number of participants limited to 24.

Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have

Abstract

Review of some non-standard regression models and the statistical properties of estimation methods in such models.

Objective

The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).

Content

Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, 

1. Monotone regression
2. Single index model
3. Unlinked regression

Student Seminar in Statistics: Inference in Some Non-
In the following is the tentative material that will be read and studied by each pair of students (all the items listed below are available through the ETH electronic library or arXiv). Some of the items might change.


8. "Linear regression with shuffled data: statistical and computation limits of permutation recovery" by A. Pananjady, M. Wainwright and T. A. Courtade, 2018, IEEE transactions in Information Theory, Volume 64, 3286-3300

9. "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS


11. "Uncoupled isotonic regression via minimum Wasserstein deconvolution" by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27

Prerequisites / notice

The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

- **Literature**
- **Prerequisites / notice**
- **Abstract**

### Science in Perspective

- **Abstract**

### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>261-0800-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

#### Master's Thesis

The minimal prerequisites for the Master's thesis registration are:

- Completed Bachelor's program
- All additional requirements completed (additional requirements, if any, are listed in the admission decree)
- Minimum degree requirements fulfilled of the course categories Data Analysis and Data Management and overall 50 credits obtained in the course category Core Courses
- Data Science Lab (14 credits) completed

**Abstract**

The Master’s thesis concludes the study program and demonstrates the students’ ability to use the knowledge and skills acquired during Master’s studies to solve a complex data science problem.

**Objectives**

To work independently and to produce a scientifically structured work.

### Data Science Master - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
<th>W</th>
<th>Eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
</tbody>
</table>

**Key for Hours**

| V   | lecture                  | P    | practical/labatory course |
| G   | lecture with exercise    | A    | independent project |
| U   | exercise                 | D    | diploma thesis |
| S   | seminar                  | R    | revision course / private study |
| K   | colloquium               |      |                       |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement

Abstract
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

Objective
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content
The seminar covers the following topics:
1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

Literature
Literature will be made available to the participants.

Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

Prerequisites / notice
Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

Subject Specialisation

Scientific Machine and Deep Learning for Design and Construction in Civil Engineering

Abstract
This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

Objective
This course aims to provide graduate level introduction into Machine and especially scientific Machine Learning for applications in the design and construction phases of projects from civil engineering.

Upon completion of the course, the students will be able to:
1. understand main ML background theory and methods
2. assess a problem and apply ML and DL in a computational framework accordingly
3. Incorporating scientific domain knowledge in the SciML process
4. Define, Plan, Conduct and Present a SciML project

Content
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

Literature
Suggested Reading:
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016

Prerequisites / notice
Familiarity with MATLAB and / or Python is advised.
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

Objective

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

Content

The course will assess if this has not resulted in disqualification of the material and formal presence of architecture in our history writing.

This threefold change in architectural historiography seems to coincide with a shift in the contemporary discourses on the changing role of the architect, the cooperative character of architectural practice and the renewed interest in the craft. The course will question the

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In an era of postcolonial theory and reflection, architectural historiography is faced with a series of new challenges and ambitions, concerning its subjects and its methods.

This course will reflect upon three of them: the death of the author, center and meta-theory. A first point investigates how recent scholarship seems to dissociate from histories of single and all-decisive authors, to make way for perspectives that render buildings and neighborhoods as a matter of negotiation between multiple agencies. Second, this course will dwell upon the Euro-American bias of our histories, as well as its implicit center-periphery model, and look at recent attempts to tell more cross-cultural historiographies of architecture. Third, the course will discuss the strong meta-theoretical bias of postcolonial historiography (using theories of power, alterity, gender) and question if this has not resulted in disqualification of the material and formal presence of architecture in our history writing.

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For Architecture doctoral program only.

Abstract

Corrective historiographies for architectural research

Objective

Acquiring insight into advanced research methods available to PhD-researchers in the fields of the history and theory of art and architecture.

Content

In an era of postcolonial theory and reflection, architectural historiography is faced with a series of new challenges and ambitions, concerning its subjects and its methods.

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This threefold change in architectural historiography seems to coincide with a shift in the contemporary discourses on the changing role of the architect, the cooperative character of architectural practice and the renewed interest in the craft. The course will question the

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

The seminar addresses the fellows of the Doctoral Program in History and Theory of Architecture. All other doctoral students of the Faculty of Architecture are welcome.

The course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Fostered competencies

Subject-specific Competencies: Concepts and Theories, Analytical Competencies, Problem-solving
Method-specific Competencies: Communication
Social Competencies: Self-presentation and Social Influence
Personal Competencies: Critical Thinking

Literature


064-0005-22L Advanced Topics in History and Theory of Architecture

| W | 1 credit | 1K | T. Avermaete, M. Delbeke, L. Stalder, P. Ursprung

Prerequisites / notice

The seminar addresses the fellows of the Doctoral Program in History and Theory of Architecture. All other doctoral students of the Faculty of Architecture are welcome.
PhD Colloquium Theory of Information Technology for Architects

Abstract
Introduction to methodological approaches in the history and theory of architecture; presentation and discussion of individual doctoral projects.

Objective
The two-semester course in the first year of the doctoral program in the history and theory of architecture has a twofold objective: First, method sessions on central approaches in the history and theory of architecture provide a methodological basis for the doctorate at the Institute gta. Secondly, in "practice" sessions, the doctoral students get support for their individual research projects and guidance for the production of the Research Plan they have to present at the end of the first year.

Content
“Again. If a thing can be done adequately by means of one, it is superfluous to do it by means of several; for we observe that nature does not employ two instruments where one suffices.”

The methodology of humanistic research grows more complex with every academic generation: it presents a thicket of epistemological frameworks rather than a straightforward array of tools. In the omnivorous field of architectural history and theory, the scholar faces a further set of possible approaches to any individual research subject. This course considers the variety of available strategies for the creation of architectural histor(ies) and theor(ies) as an opportunity for intellectual inquiry distinctive to our discipline. Through close and prolonged study of a range of historically significant or methodologically innovative writing, we will deepen our understanding both of how other historians have structured their work as well as refine each student’s developing research methodology.

The course, held over two semesters, combines a traditional doctoral theory seminar with a practical writing workshop: we will alternate reading-based discussions with working sessions directed towards the development of the research proposal to be submitted at the end of the first year.

The course schedule will be available at the beginning of HS 2022 on the course website: https://doctoral-program.gta.arch.ethz.ch/courses/research-methods-in-the-history-and-theory-of-architectureHS22e

Please note doctoral program courses begin the third week of the semester.

Lecture notes
Scans of selected texts for discussion and exercises will be provided at the beginning of HS 2022 on the course moodle page (registered students only):
https://moodle-app2.let.ethz.ch/course/view.php?id=18309

Prerequisites / notice
Required for first-year gta doctoral students; other doctoral students and gta MAS accepted by application, space permitting.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Method-specific Competencies</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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PhD Colloquium Theory of Information Technology for Architects

Abstract
Information technology plays an increasingly important role in research. To meet this challenging development, it is not only important to acquire respective skills, but also to consider and understand information technology in what sets it apart from other gestalts of technics (like mechanics, dynamics, or thermodynamics).

Objective
The aim of this colloquium is to counter an observable tendency, that proportional to the degree in which students master practical skills in computing, they increasingly submit uncritically, in their understanding and framing of problems, to the dictation of schemata and templates implemented by technical systems.

Content
The starting point for this colloquium is to comprehend computing not in terms of skills, but as a literacy which we can experience emerging today. Like in the case of writing as well, computing cannot exhaustively be reduced to either logics, grammar, arithmetics, or analytics. Rather, computation, if comprehended as a literacy, relates to any of the established categories of learning and raises questions of an architectonic kind. This colloquium draws from the principal richness of cultural forms of knowing and learning and thematizes approaches to formulate a theoretical stance on information technology for architects which is driven by and resting on the actual reality of computability today. In this, it is complementary to those theory courses on technology offered by the historical disciplines at ETH.

Prerequisites / notice
To benefit from this course, you should have a practical affinity to technics, as well as an abstract interest in information technology in its comprehensive cultural context.

Research Methods in Landscape and Urban Studies: Writing Landscapes, Writing the Urban

Abstract
This seminar supports researchers writing on topics related to landscape, urban studies, and architecture through offering hands-on guidance and a safe space for peer-to-peer exchange. The seminar participants receive guidance on how to work with fieldwork, literature reviews, and archival research, develop arguments and narrative arcs in writing.

Research Methods in the History and Theory of Architecture

Abstract
Introduction to methodological approaches in the history and theory of architecture; presentation and discussion of individual doctoral projects.

Objective
The two-semester course in the first year of the doctoral program in the history and theory of architecture has a twofold objective: First, method sessions on central approaches in the history and theory of architecture provide a methodological basis for the doctorate at the Institute gta. Secondly, in "practice" sessions, the doctoral students get support for their individual research projects and guidance for the production of the Research Plan they have to present at the end of the first year.

Content
“Again. If a thing can be done adequately by means of one, it is superfluous to do it by means of several; for we observe that nature does not employ two instruments where one suffices.”

The methodology of humanistic research grows more complex with every academic generation: it presents a thicket of epistemological frameworks rather than a straightforward array of tools. In the omnivorous field of architectural history and theory, the scholar faces a further set of possible approaches to any individual research subject. This course considers the variety of available strategies for the creation of architectural histor(ies) and theor(ies) as an opportunity for intellectual inquiry distinctive to our discipline. Through close and prolonged study of a range of historically significant or methodologically innovative writing, we will deepen our understanding both of how other historians have structured their work as well as refine each student’s developing research methodology.

The course, held over two semesters, combines a traditional doctoral theory seminar with a practical writing workshop: we will alternate reading-based discussions with working sessions directed towards the development of the research proposal to be submitted at the end of the first year.

The course schedule will be available at the beginning of HS 2022 on the course website: https://doctoral-program.gta.arch.ethz.ch/courses/research-methods-in-the-history-and-theory-of-architectureHS22e

Please note doctoral program courses begin the third week of the semester.

Lecture notes
Scans of selected texts for discussion and exercises will be provided at the beginning of HS 2022 on the course moodle page (registered students only):
https://moodle-app2.let.ethz.ch/course/view.php?id=18309

Prerequisites / notice
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Objective

Research writing can often be a solitary, arduous, and unrewarding exercise, this seminar aims to promote peer-to-peer exchange, and offer hands-on guidance and a safe space for researchers writing on topics related to landscape, urban studies, and architecture. The seminar will offer guidance as to how researchers can work with fieldwork, literature reviews, and archival research, develop arguments and narrative arcs in writing, in addition to practical tips and tricks. While the seminar is primarily geared towards supporting doctoral researchers in the dissertation-writing phase, it is open to all researchers regardless of where they might be in their research provided they are in the process of developing a work of academic writing such as research plan, a journal article, or a design manifesto.

The participants of this seminar are expected to bring a text that they would like to develop over the course of the semester. The texts can be diverse in format and length; it can be a dissertation or book chapter, journal or magazine article, or a research plan.

The seminar will alternate between inputs by invited guests, reading and discussion sessions, tutorials, and peer-review. A total of five input lectures by invited guests will be offered during the seminar, where senior academics from the Department and elsewhere will provide a behind-the-scenes look into their writing process. The invited guests will discuss as to how they structure their arguments, organise their sources and materials, and how they find inspiration for their writing process. These input lectures will be alternated with thematically organised tutorial sessions structured around the following themes: writing about fieldwork and field methods, about landscapes, about political ecology and economy, ethnographic human and other-than-human vignettes, about dwelling and urban space. In the first half of these tutorial sessions, the seminar participants will discuss and debate a requisite reading followed by a writing tutorial and feedback session based on the texts. The seminar participants can choose to present the work developed during the seminar at the LUS Doctoral Crits organised at the end of the semester.

Content

The format will provide an overarching methodological meta-theme, to be defined prior to the event. One external guest critic will be invited.

In this case, each presentation will conclude with a discussion round, providing sufficiently detailed feedback for every doctoral candidate.

Lecture notes

22.09 – EXERCISES IN STYLE
29.09 – Ethnography from the field and archive – ADAM JASPER
06.10 – Writing spatially, writing otherwise - MATTHEW CRITCHLEY
13.10 – Indigenous Landscape Urbanism – KELLY SHANNON
03.11 – Informed gardening activism - BARBARA VAN DYCK
10.11 – Ordering the unfamiliar - ANNE HULTZSCH
17.11 – Landscape, dwelling, and the political ecology - MAAN BARUA
24.11 – From notes to narrative - NIKOS MAGOULIOTIS
01.12 – Imagining the invisible - NANCY COULING
08.12 – Writing in the Planetary Age - HOLLYAMBER KENNEDY
15.12 – LUS Doc Crits

Prerequisites / notice

064-00025-22L Introduction to Computational Research in Architecture, Engineering, Fabrication and Construction

Does not take place this semester.
The PhD-level course (primarily for A&T PhDs) will introduce computational methods for architecture, engineering, fabrication & construction, incentivising computational literacy. Students learn the theoretical background and basic implementation details of fundamental data structures and algorithms, and to solve real-world problems using the COMPAS framework and other open-source libraries.

**Objective**

Understand the scope and relevance of computational methods for architecture and engineering research and practice, i) the theoretical background of fundamental data structures, ii) the basic principles of algorithmic design; iii) implement basic versions of prevalent algorithms related to architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation; iv) use sophisticated algorithms available through open-source libraries to solve real-world problems; and, v) use common CAD tools as interfaces to self-implemented solutions.

**Content**

Course consists of a few lectures, several tutorials and project-based exercises. Topics include:

- intro Python programming
- intro COMPAS open-source framework (https://compas-ev.github.io)
- intro to geometry processing, data structures, topology, numerical computation
- specific case studies (e.g. on architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation)

**Prerequisites / notice**

Priority is given to PhD students.

| 064-0027-22L | PhD Colloquium CASA (Institute IEA) | W | 2 credits | 2K | E. Mosayebi |

**Abstract**

The summer school intends to renegotiate and experiment with the ways we – as researchers and spatial practitioners – perform writing, as a format and as a practice. In the set-up of a collaborative writing retreat. The participants are expected to take their PhD Colloquium CASA (Institute IEA) 3K P. Ursprung

**Objective**

The summer school foresees a summer school in the form of a collaborative writing retreat. The participants are expected to take their PhD Colloquium CASA (Institute IEA) 3K P. Ursprung

**Content**

Course consists of a few weeks, several tutorials and project-based exercises. Topics include:

- intro Python programming
- intro COMPAS open-source framework (https://compas-ev.github.io)
- intro to geometry processing, data structures, topology, numerical computation
- specific case studies (e.g. on architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation)

**Prerequisites / notice**

Priority is given to PhD students.

| 064-0027-22L | PhD Colloquium CASA (Institute IEA) | W | 2 credits | 2K | E. Mosayebi |

**Abstract**

The summer school aspires to establish a peer group of early-career scholars that stay connected beyond the summer school. By the end of the workshop, the participants will have:

- acquired skills on new writing methods
- discussed learning and writing outcomes collectively
- gained the opportunity to take the role of an editor of their colleagues work
- gained experience in presenting their work-in-progress in an informal setting

**Content**

The programme foresees a summer school in the form of a collaborative writing retreat. The participants are expected to take their individual research as a starting point and develop it further during their stay. Selected invited experts will host writing workshops on themes like creative writing, site writing and multi-perspectival writing. Additionally, two sensorial workshops hosted by artists on the themes of sound and smell aim to inspire and enrich the writing practice and connect the participants to the place. All workshops will serve as input sessions and are followed by individual writing periods, where participants get the chance to test the methods acquired in the expert workshops. Individual writing sessions are then followed by group sessions where the material is collectively discussed. The format aims at generating a non-hierarchical learning environment, a peer group where colleagues collectively progress their writing by exploring new methods and perspectives.

The summer school is articulated through the synthesis of three different formats:

- workshops organized by external guests offering insights to the participant
- individual writing sessions for the participants to develop their material
- collective peer-to-peer discussion aiming at exchange and the formation of a peer-group

**Writing Workshops**

- Room and Field, Writing One with Another: a Site-Writing Workshop with Jane Rendell and Polly Gould
- Exploring Sensorial Practices
  - Writing with sound, by Ludwig Berger, sound artist
  - Follow your nose, by Curdin Tones, community-artist
  - With Collective Cooking Sessions and Fountain Bathing curated by the community-artist Curdin Tones

**Lecture notes**

Teaching involves 3 full workshop days, 1 self-study day and one final review day.

Place: The summer school is organized at the Alpine village of Tschlin in Graubünden, Switzerland. Participants will be hosted at three local houses. Common workshops will be organized at the venue of the local school and at the artistic residency space of Somalgors74. The summer school explores a form of inhabitation that is neither touristic nor individual and allows for reflection and redefinition of what it means to retreat: We want to see retreating not as isolating and detouching but rather as engaging with localities and situating ourselves.

Date: The summer school will take place on 11 – 16 September 2022.

**Organisers**

Metaxia Markaki (ETHZ), Johanna Just (ETHZ), Sila Karatas (EPFL)

**Prerequisites / notice**

Participation fees cover accommodation and selected meals (all lunches and 2 dinners):

- 250CHF (ETHZ/EPFL doctoral students)
- 350CHF external doctoral students; ETHZ/ EPFL Mittelbau with a strong interest in writing.

All participants are required to take part in the full 6 day programme. (Arrival 11.9, programme 12-16.9) Applicants will submit a writing sample related to their dissertation and a CV.
This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional understanding of analytical competencies.

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

The project addresses critical issues of urban planning by using cutting-edge technology for analysis and communication. Students actively engage with building and zoning regulations ((i) reconstruct, (ii) reformulate and (iii) simulate/virtualise in web-based 4D urban models) as well as maintain an ongoing exchange through (peer) review activities in class.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

Before registering, please ensure you also register for 351-0778-00L. Please register before 6.6.22.

Abstract
The project addresses critical issues of urban planning by using cutting-edge technology for analysis and communication. Students actively engage with building and zoning regulations ((i) reconstruct, (ii) reformulate and (iii) simulate/virtualise in web-based 4D urban models) as well as maintain an ongoing exchange through (peer) review activities in class.

Objective
- Capture and analyse the past and present; design, present and discuss future living spaces in 4D.
- Read, understand, deconstruct and formulate new zoning and building rules (BNO(s).
- Set up an ArcGIS Urban model and integrate current and new urban rules and visualize/simulate development scenarios/variations of urban designs.
- Learn from students from different disciplines through teamwork and by peer-reviewing each other’s work.
- System thinking through causal loops.

Content
This planned course addresses the crucial urban transformation issues of our time at the 10-minute-neighbourhood level. Technology, communication and online learning materials are leveraged and opportunities for online interaction are combined with traditional place-based teaching methods. The course can be taught as elective with exercise and as an integrated discipline in design classes. In addition, the online material can be used for self-paced learning.

(i) Students actively engage with building and land use regulations by reconstructing them in a 3D model, formulating new 3D regulations based on design and land use criteria, and simulating possible developments based on existing building criteria in 4D. As students from different disciplines work in teams and share knowledge through mutual work and peer reviews, they can learn from each other across disciplines.

(ii) Urban design lecturers can benefit form being relieved of the task of teaching students software as part of the design class.

(iii) The entire degree programmes in architecture, landscape architecture, building information systems (all D-ARCH), and spatial development and infrastructure systems (D-BAUG) can benefit from this. It is also conceivable that, building on this, a joint program will be developed and offered in the future, with the integration/combination of City Energy Analysis (CEA) by Prof. Schlüter, IÖ-app by Prof. Menz, Enerpol Tool/Daylight by Prof. Klumpner, to name but a few.

Prerequisites / notice
The course is offered in summer 2022 as an elective block course with exercises, in HS22 as an integrated discipline within the Klumpner design studio and in FS23 to choose between the elective course or the integrated discipline.

351-0778-00L Discovering Management (Exercises)
Complementary exercises for the module Discovering Management.

Prerequisite: Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

Abstract
This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

Objective
The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Content
Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

Students have the option to either write this alone or in a group of two students.

Literature
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".
### Transferable Skills

<table>
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<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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**Autumn Semester 2022**
**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

<table>
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<tr>
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### Integration into Scientific Community

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Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days.
Objective Participation in summer or winter schools with a minimum duration of 4 days.

### 900-0159-DRL Summer School I (min 4 days, with Poster or Talk)

Only for doctoral students.

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Abstract Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

### 900-0160-DRL Summer School II (min 4 days, with Poster or Talk)

Only for doctoral students.

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Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

### 900-0161-DRL Summer School III (min 4 days, with Poster or Talk)

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

### 900-0162-DRL External Conference I (incl. Poster or Talk)

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

### 900-0163-DRL External Conference II (incl. Poster or Talk)

Only for doctoral students.

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Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

### Doctorate Architecture - Key for Type

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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 647 of 2416
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<td>K</td>
<td>colloquium</td>
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<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Seismic and Vibration Isolation

In this course, the students will learn:
- the mechanics of and design isolator bearings
- the design of seismic isolated structures: from theory to practice
- the mechanics of rubber bearings for seismic and vibration isolation

Prerequisites:
- know basic modal analysis, elastic spectrum analysis and basic structural mechanics.
- practice presentation and discussion of technical content to a broader, less specialised scientific audience
- establish links and discuss connections, common challenges and discipline-specific differences
- network people and methodological expertise across disciplines

Objective
- After successfully completing this course the students will be able to:
  1. Understand the mechanics of and design isolator bearings.
  2. Understand the dynamics of and design an isolated structure.

Content
1. Introduction: Overview of seismic isolation; review of structural dynamics and earthquake engineering principles. Viscoelastic behavior.
2. Linear theory of seismic isolation
3. Types of seismic isolation devices - Modelling of seismic isolation devices – Nonlinear response analysis of seismically isolated structures in Matlab
4. Behavior of rubber isolators under shear and compression
5. Behavior of rubber isolators under bending
6. Buckling and stability of rubber isolators
7. Code provisions for seismically isolated buildings

Literature
- There is no single textbook for this course. However, most of the lectures are based on parts of the following books:
  - Dynamics of Structures, Theory and Applications to Earthquake Engineering, 4th edition, Anil Chopra, Prentice Hall, 2017
  - Design of seismic isolated structures: from theory to practice, Farzad Naeim and James M. Kelly, John Wiley & Sons, 1999
  - Mechanics of rubber bearings for seismic and vibration isolation, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011

Prerequisites / notice
- Mechanics of rubber bearings for seismic and vibration isolation, James M. Kelly and Dimitrios Konstantinidis, John Wiley & Sons, 2011
- 101-0157-01 Structural Dynamics and Vibration Problems course, or equivalent, or consent of the instructor. Students are expected to know basic modal analysis, elastic spectrum analysis and basic structural mechanics.

Number of participants limited to 21.

Fatigue and Fracture in Materials and Structures

The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

In this course, the students will learn:
- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.

Prerequisites / notice
- This doctoral seminar is intended for doctoral students affiliated with the Department of Civil, Environmental and Geomatic Engineering. Other students who work on related topics need approval by at least one of the organisers to register for the seminar.
- Participants are expected to possess elementary skills in statistics, data science and machine learning, including both theory and practical modelling and implementation. The seminar targets students who are actively working on related research projects.
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Elastic/linear elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Plastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and "Laboratory Competition". The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- "Laboratory Competition" at Empa: the students with the closest predictions will win the "Empa Laboratory Competition" and will be awarded by a prize.

Lecture notes
Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Literature

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

Scientific Machine and Deep Learning for Design and Construction in Civil Engineering

This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.

Upon completion of the course, the students will be able to:
1. understand main ML background theory and methods
2. assess a problem and apply ML and DL in a computational framework accordingly
3. Incorporating scientific domain knowledge in the SciML process
4. Define, Plan, Conduct and Present a SciML project

The course aims to provide graduate level introduction into Machine and especially scientific Machine Learning for applications in the design and construction phases of projects from civil engineering.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a "hands-on" feel for the course topics.

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Suggested Reading:
- Marc Peter Deisenroth, A Aldo Faisal, and Cheng Soon Ong Mathematics for Machine Learning
- S. Guido, A. Müller: Introduction to machine learning with python. O'Reilly Media, 2016
- G. Martin: Bayesian analysis with python, Packt Publishing Ltd, 2016

Familiarity with MATLAB and / or Python is advised.

This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.
### Objective
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect on their own research project in its societal context and on their role as scientists.

### Content
The seminar covers the following topics:
1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

### Literature
The following open access article builds a core element of the course:

Further, this collection of tools will be used:
https://naturalsciences.ch/topics/co-producing_knowledge

### Prerequisites / notice
- Participation in the course requires participants to be working on their own research project.
- Dates (Wednesdays, 8h15-12h00): 29 September, 12 October, 26 October, 9 November, 23 November

### Fostered competencies
- Subject-specific Competencies: Concepts and Theories
- Problem-solving
- Cooperation and Teamwork
- Critical Thinking
- Self-awareness and Self-reflection

### Prerequisites / notice
- Literature will be made available to the participants.
- See school brochure: https://ln5.sync.com/dl/ad79f3fe0/xjtbmmdc-mdwngx2b-5uh5cv5g-9e8y7vgk

### Literature
The following open access article builds a core element of the course:
101-0523-13L Frontiers in Machine Learning Applied to Civil, Env. and Geospatial Engineering (HS22)

### 102-1227-22L Prospectives Life Cycle Assessment (Summer School: W 3 credits 6S C. L. Mutel

### Abstract
This 5-day Autumn School, held from Oct. 24-28 in Grosshochstetten, will be on the use of open source software to supplement, modify, disaggregate, and time-shift life cycle inventory data. Students will have 5-6 teaching modules and a then work with an assistant on a group project.

As it is held in a seminar hotel, there is a fee for this course.

### Objective
- To learn how inventory datasets can be treated as a set of claims about the world instead of pre-packaged and complete pictures.
- To understand how Brightway and Premise can be used to modify LCA and supplementary databases.
- To conduct time- and space-differentiated life cycle assessment.

### Content
See school brochure: https://ln5.sync.com/dl/ad79f3fe0/xjtbmmdc-mdwngx2b-5uh5cv5g-9e8y7vgk

In the first half of this summer school, we will have a series of interactive exercises that will demonstrate when, how, and why to use different software modules to solve specific data problems. In the second half, small groups will apply these ideas to create their own tailored inventory databases.

The school will build exclusively on open source software.

### Prerequisites / notice
- Some basic understanding of Python will be necessary.
- Students will have a series of online exercises to complete in the month before the school so that we have a common foundation to build upon.

Registered students will be given a set of Python basic tasks and tutorial notebooks, as well as Jupyter notebook homework tasks to be done before the Autumn School.
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<tr>
<th>Number</th>
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Objective  Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL  Member of Executive Board (min 1 year)  
Only for doctoral students.
Abstract  Active participation in the presidium or executive board of a university group for at least 1 year.
Objective  Active participation in the presidium or executive board of a university group for at least 1 year.

101-5000-00L  Ethics and Scientific Integrity for Doctoral Students of D-BAUG  
C. Sailer  
Abstract  This course sensitises doctoral students to ethical issues that may arise during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students are given the opportunity to apply their knowledge and train their newly acquired skills in an interactive, discipline specific context.
Objective  Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. Furthermore, they are encouraged to reflect on their professional role as scientific researchers.
Content  Part I  
The self-paced e-learning course consists of 5 modules:
Module 1: Ethics  
Introduction to moral theory (with emphasis on practical guidance regarding decision making)
Module 2: Ethics in scientific research  
Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).
Module 3: Collecting resources  
A variety of tools and resources that help identify ethical issues are presented and explained
Module 4: Setting up a strategy  
Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).
Module 5: Making decisions  
Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices or solve ethical dilemmas).
Part II  
The second, face-to-face part of this course focuses on discipline-specific aspects in the general area of Environmental Sciences. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.
Prerequisites / notice  For doctoral students only. Course

Integration into Scientific Community

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| 900-0151-DRL  | Summer School II (1-3 days)  | W    | 1    | 2K    | Lecturers |
Abstract  Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
Objective  Participation in summer or winter schools with a maximum duration of 3 days.

| 900-0152-DRL  | Summer School III (1-3 days)  | W    | 1    | 2K    | Lecturers |
Abstract  Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
Objective  Participation in summer or winter schools with a maximum duration of 3 days.
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| Objective    | Participation in summer or winter schools with a maximum duration of 3 days. |

| 900-0155-DRL | Summer School III (1-3 days, with Poster or Talk) | W | 2 credits | 4K | Lecturers |
| Abstract     | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |
| Objective    | Participation in summer or winter schools with a maximum duration of 3 days. |

| 900-0156-DRL | Summer School I (min 4 days) | W | 2 credits | 4K | Lecturers |
| Abstract     | Participation in summer or winter schools with a minimum duration of 4 days. |
| Objective    | Participation in summer or winter schools with a minimum duration of 4 days. |

| 900-0157-DRL | Summer School II (min 4 days) | W | 2 credits | 4K | Lecturers |
| Abstract     | Participation in summer or winter schools with a minimum duration of 4 days. |
| Objective    | Participation in summer or winter schools with a minimum duration of 4 days. |

| 900-0158-DRL | Summer School III (min 4 days) | W | 2 credits | 4K | Lecturers |
| Abstract     | Participation in summer or winter schools with a minimum duration of 4 days. |
| Objective    | Participation in summer or winter schools with a minimum duration of 4 days. |

| 900-0159-DRL | Summer School I (min 4 days, with Poster or Talk) | W | 3 credits | 6K | Lecturers |
| Abstract     | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |
| Objective    | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0160-DRL | Summer School II (min 4 days, with Poster or Talk) | W | 3 credits | 6K | Lecturers |
| Abstract     | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |
| Objective    | Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. |
### Summer School III (min 4 days, with Poster or Talk)

**W 3 credits 6K Lecturers**

*Only for doctoral students.*

**Abstract**
 Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

**Objective**
 Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

### External Conference I (incl. Poster or Talk)

**W 1 credit 2K Lecturers**

*Only for doctoral students.*

**Abstract**
 Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Objective**
 Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

### External Conference II (incl. Poster or Talk)

**W 1 credit 2K Lecturers**

*Only for doctoral students.*

**Abstract**
 Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Objective**
 Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

### External Conference III (incl. Poster or Talk)

**W 1 credit 2K Lecturers**

*Only for doctoral students.*

**Abstract**
 Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Objective**
 Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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**Doctorate Civil, Environmental and Geomatic Engineering - Key for Type**

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<thead>
<tr>
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<th>Compulsory</th>
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<tr>
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</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
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**Key for Hours**

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<thead>
<tr>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Introductory Course in Neuroscience I (University of Zurich)

*No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*

**UZH Module Code:** SPV0Y005

- **ECTS:** 2 credits
- **Hours:** 2V
- **Lecturers:** University lecturers

**Abstract**
The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.

**Objective**
The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.

**Content**
1. Human Neuroanatomy I&II
2. Comparative Neuroanatomy
3. Building a central nervous system I&II
4. Synapses I&II
5. Glia and more
6. Excitability
7. Circuits underlying Emotion
8. Visual System
9. Auditory & Vestibular System
10. Somatosensory and Motor Systems
11. Learning in artificial and biological neural networks

**Prerequisites / notice**
For doctoral students of the Neuroscience Center Zurich (ZNZ).
Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Problem-solving
Self-awareness and Self-reflection
Self-direction and Self-management

Abstract
The course consists of a series of research seminars on Structural Biology, Biochemistry and Biophysics, given by both scientists of the National Center of Competence in Research (NCCR) in Structural Biology and external speakers. Information on the individual seminars is provided on the following websites:
http://www.structuralbiology.uzh.ch/educ002.asp
http://www.biol.ethz.ch/dbiol-cal/index

Objective
The goal of this course is to provide doctoral and postdoctoral students with a broad overview on the most recent developments in biochemistry, structural biology and biophysics.

551-1619-00L Structural Biology

Abstract
The course consists of a series of research seminars on Structural Biology, Biochemistry and Biophysics, given by both scientists of the National Center of Competence in Research (NCCR) in Structural Biology and external speakers. Information on the individual seminars is provided on the following websites:
http://www.structuralbiology.uzh.ch/educ002.asp
http://www.biol.ethz.ch/dbiol-cal/index

Objective
The goal of this course is to provide doctoral and postdoctoral students with a broad overview on the most recent developments in biochemistry, structural biology and biophysics.

551-1109-00L Seminars in Microbiology

Abstract
Seminars by invited speakers covering selected microbiology themes.

Objective
Discussion of selected microbiology themes presented by invited speakers.

551-0512-00L Current Topics in Molecular and Cellular Neurobiology

Abstract
The course is a literature seminar or "journal club". Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.
The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

Presentations will be made available after the seminars.

Prerequisites / notice

You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

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<thead>
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<td>551-0509-00L</td>
<td>Current Immunological Research in Zurich</td>
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<td>551-1615-00L</td>
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<td>551-1409-00L</td>
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<td>551-1407-00L</td>
<td>RNA Biology Lecture Series I: Transcription &amp; Processing &amp; Translation</td>
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<td>701-0015-00L</td>
<td>Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement</td>
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<td>B. Vienni Baptista</td>
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Data: 01.11.2022 12:41
Autumn Semester 2022
Page 659 of 2416
The seminar covers the following topics:
(1) Theories and concepts of inter- and transdisciplinary research
(2) The specific challenges of inter- and transdisciplinary research
(3) Collaborating between different disciplines
(4) Engaging with stakeholders
(5) 10 steps to make participants’ research projects more societally relevant
Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

The first lecture will serve to form groups of students and assign papers.

The number of participants is limited to 22 and will only take place with a minimum of 11 participants.

Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bml@ethz.ch using in the subject: 551-0357-00.
In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The following open access article builds a core element of the course:
available at (open access): http://www.ingentaconnect.com/content/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used
https://naturalsciences.ch/topics/co-producing_knowledge

Participation in the course requires participants to be working on their own research project.

551-0357-00L
Cellular Matters: From Milestones to Open Questions

W 4 credits 2S


In this course, the students will explore the quite new topic of biomolecular condensates.

In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that lever on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the processes, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

The presentations will be made available after the lectures.

The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Self-reflection: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Transferable Skills

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<th>Number</th>
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<td>900-0101-DRL</td>
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<td>Only for doctoral students.</td>
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<td>2P</td>
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</table>
900-0113-DRL Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Only for doctoral students.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) W 2 credits 4P Lecturers

Only for doctoral students.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

701-0703-00L Environmental Ethics W 2 credits 2V A. Deplazes Zemp

Abstract
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Content
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Lecture notes
Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

Literature
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O'Neill et al., Environmental Values, 2008
- Konrad Ott/Jan Dierks/Lieske Voget-Kleschin, Handbuch Umweltethik, 2016

Prerequisites / notice
The procedure for accumulating CP will be explained at the start of term.
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

851-0180-00L Research Ethics W 2 credits 2G G. Achermann, P. Emch

Number of participants limited to 40

Abstract
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective
Participates of the course Research Ethics will

- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning

1. Ethics - the basics
   1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
   2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
   3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct
   1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
   2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
   3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities

1. Research involving human subjects
   1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
   2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
   3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!): 1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises. 2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Fostered competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
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851-0745-00L Ethics Workshop: The Impact of Digital Life on Society  
Number of participants limited to 40.

Open to all Master level / PhD students.

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.

Objective
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

<table>
<thead>
<tr>
<th>Course Code</th>
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<td>376-1661-00L</td>
<td>Ethics of Life Sciences and Biotechnology</td>
<td>3</td>
<td>Fall</td>
<td>A. Blasimme, E. Vayena</td>
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<td>851-0178-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students</td>
<td>1</td>
<td>Spring</td>
<td>G. Achermann, E. Bobst, N. Gruber, E. Vayena</td>
</tr>
</tbody>
</table>

### Content

- The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.
- A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

### Abstract

- This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

### Objective

- This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

  A. Identify ethical issues in in life sciences and biotechnology.
  B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
  C. Become aware of relevant legal and public policy frameworks.
  D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
  E. Recognize how ethical issues relate to different accounts of technology and innovation.
  F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
  G. Autonomously anticipate ethical issues.
  H. Propose and communicate solutions to ethical challenges and dilemmas.

### Methods

- The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.
- The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.
- All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

### Personal Competencies

- Self-awareness and Self-reflection
- Critical Thinking
- Negotiation
- Creativity

### Social Competencies

- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Negotiation

### Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Negotiation
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

### Personal Competencies

- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection

### Social Competencies

- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Negotiation

### Content

- The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.
- The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.
- All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

### Abstract

- This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

### Objective

- Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.
Part I on Moodle
The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II).

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

Fostered competencies

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<thead>
<tr>
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Integration into Scientific Community

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 666 of 2416
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Data: 01.11.2022 12:41   Autumn Semester 2022   Page 667 of 2416
and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Doctorate Biology - Key for Type

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<td>W+</td>
<td>Eligible for credits and recommended</td>
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Key for Hours

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<th>P</th>
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<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tr>
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</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This seminar will feature invited lectures about recent advances and developments in systems biology, including topics from biology, bioengineering, and computational biology.

Objective
To provide an overview of current systems biology research.

Content
The final list of topics will be available at [https://www.bsse.ethz.ch/news-and-events/seminar-series.html](https://www.bsse.ethz.ch/news-and-events/seminar-series.html)

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0309-00L</td>
<td>Advances in Molecular Biotechnology</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>M. Fussenegger</td>
</tr>
</tbody>
</table>

Abstract
This seminar features the latest progress in molecular biotechnology, including topics from bioengineering, synthetic biology as well as gene- and cell-based therapies.

Objective
To provide an overview of current strategies to engineer mammalian cells.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0009-00L</td>
<td>Evolutionary Dynamics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+2A</td>
<td>N. Beerenwinkel</td>
</tr>
</tbody>
</table>

Abstract
Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

Objective
The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Content
Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

Lecture notes
No.

Literature

Prerequisites / notice
Prerequisites: Basic mathematics (linear algebra, calculus, probability)

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>636-0104-00L</td>
<td>Biophysical Methods</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. J. Müller</td>
</tr>
</tbody>
</table>

Abstract
Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective
Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content
The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

Lecture notes
Hand out will be given to students at lecture.
Methods in Molecular Biophysics (5th edition), Serdyuk et al., Cambridge University Press
Cell Biology, Pollard & Earnshaw; ISBN-0-7216-3997-6, Saunder, Pennsylvania

The module is composed of 3 SWS (3 hours/week): 2-hour lecture, 1-hour seminar. For the seminar, students will prepare oral presentations on specific in-depth subjects with/under the guidance of the teacher.

636-0706-00L Spatio-Temporal Modelling in Biology W 4 credits 3G D. Iber
Abstract
This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on mechanisms and concepts, but mathematical and numerical techniques are introduced as required. Biological examples discussed in the course provide an introduction to key concepts in developmental biology.

Objective
Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classic as well as current approaches and exposes students to many open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Content
1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Lecture notes
All lecture material will be made available online via Moodle.

Literature
The lecture course is not based on any textbook. The following textbooks are related to some of its content. The textbooks may be of interest for further reading, but are not necessary to follow the course:

- Murray, Mathematical Biology, Springer
- Forgacs and Newman, Biological Physics of the Developing Embryo, CUP
- Keener and Sneyd, Mathematical Physiology, Springer
- Fall et al. Computational Cell Biology, Springer
- Szallasi et al, System Modeling in Cellular Biology, MIT Press
- Wolkenhauer, Systems Biology
- Keyszig, Engineering Mathematics, Wiley

Prerequisites / notice
The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

636-0117-00L Mathematical Modelling for Bioengineering and Systems Biology W 4 credits 3G D. Iber
Abstract
Basic concepts and mathematical tools to explore biochemical reaction kinetics and biological network dynamics.

Objective
The course enables students to formulate, analyse, and simulate mathematical models of biochemical networks. To this end, the course covers basic mathematical concepts and tools to explore biochemical reaction dynamics as well as basic concepts from dynamical systems theory. The exercises serve to deepen the understanding of the presented concepts and the mathematical methods, and to train students to numerically solve and simulate mathematical models.

Content
Biological Reaction Modelling

636-0018-00L Data Mining I W 6 credits 3G+2A K. M. Borgwardt
Abstract
Data Mining, the search for statistical dependencies in large databases, is of utmost important in modern society, in particular in biological and medical research. This course provides an introduction to the key problems, concepts, and algorithms in data mining, and the applications of data mining in computational biology.

Objective
The goal of this course is that the participants gain an understanding of data mining problems and algorithms to solve these problems, in particular in biological and medical applications.

Content
The goal of the field of data mining is to find patterns and statistical dependencies in large databases, to gain an understanding of the underlying system from which the data were obtained. In computational biology, data mining contributes to the analysis of vast experimental data generated by high-throughput technologies, and thereby enables the generation of new hypotheses.

In this course, we will present the algorithmic foundations of data mining and its applications in computational biology. The course will feature an introduction to popular data mining problems and algorithms, reaching from classification via clustering to feature selection. This course is intended for both students who are interested in applying data mining algorithms and students who would like to gain an understanding of the key algorithmic concepts in data mining.

Tentative list of topics:
1. Distance functions
2. Classification
3. Clustering
4. Feature Selection

Lecture notes
Course material will be provided in form of slides.

Literature
Will be provided during the course.

Prerequisites / notice
Basic understanding of mathematics, as taught in basic mathematics courses at the Bachelor's level.

636-0102-10L Advanced Biotechnology Programmes Only for Biotechnologie Master, Programme Regulations
W 2 credits 3S S. Panke, Y. Benenson, P. S. Dittrich, M. Fussenegger,
Abstract This course provides an overview of modern concepts of bioengineering across different levels of complexity, from single molecules to systems, microscaled reactors to production environments, and across different fields of applications.

Objective Students will be able to recognize major developments in bioengineering across different organisms and levels of complexity and be able to relate it to major technological and conceptual advances in the underlying sciences.

Content Molecular and cellular engineering; Synthetic biology: Engineering strategies in biology; from single molecules to systems; downscaling bioengineering; Bioengineering in chemistry, pharmaceutical sciences, and diagnostics, personalized medicine.

Lecture notes Handouts during class

Literature Will be announced during the course

Fostered competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Techniques and Technologies</th>
<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
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636-0103-00L Microtechnology W 4 credits 3G A. Hierlemann

Abstract Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and -systems and all related microfabrication processes.

Objective Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.

Content - Fundamentals of semiconductors and band model
  - Fundamentals of devices; transistor and diode.
  - Silicon processing and fabrication steps
  - Silicon crystal structure and manufacturing
  - Thermal oxidation
  - Doping via diffusion and ion implantation
  - Photolithography
  - Thin film deposition: dielectrics and metals
  - Wet etching & bulk micromachining
  - Dry etching & surface micromachining
  - Microtechnological processing and fabrication sequence
  - Optional: Packaging

Lecture notes Handouts in English

Literature

Prerequisites / notice Fundamentals in physics and physicochemistry (orbital models etc.) are required, a repetitorium of fundamental physics and quantum theory at the semester beginning can be offered.

The information on the web can be updated until the beginning of the semester.

Fostered competencies

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636-0105-00L Introduction to Biological Computers W 4 credits 3G Y. Benenson

Abstract Biological computers are man-made biological networks that interrogate and control cells and organisms in which they operate. Their key features, inspired by computer science, are programmability, modularity, and versatility. The course will show how to rationally design, implement and test biological computers using molecular engineering, DNA nanothechnology and synthetic biology.

Objective The course has the following objectives:

* Familiarize students with parallels between theories in computer science and engineering and information-processing in live cells and organisms
* Introduce basic theories of computation
* Introduce approaches to creating novel biological computing systems in non-living environment and in living cells including bacteria, yeast and mammalian/human cells.

The covered approaches will include
- Nucleic acids engineering
- DNA and RNA nanotechnology
- Synthetic biology and gene circuit engineering
- High-throughput genome engineering and gene circuit assembly

* Equip the students with computer-aided design (CAD) tools for biocomputing circuit engineering. A number of tutorials will introduce MATLAB SimBiology toolbox for circuit design and simulations
* Foster creativity, research and communication skills through semester-long "Design challenge" assignment in the broad field of biological computing and biological circuit engineering.
Lecture 1. Introduction: what is molecular computation (part I)?

* What is computing in general?
* What is computing in the biological context (examples from development, chemotaxis and gene regulation)
* The difference between natural computing and engineered biocomputing systems

Lecture 2: What is molecular computation (part II) + State machines

1st hour

* Detailed definition of an engineered biocomputing system
* Basics of characterization
* Design challenge presentation

2nd hour

* Theories of computation: state machines (finite automata and Turing machines)

Lecture 3: Additional models of computation

* Logic circuits
* Analog circuits
* RAM machines

Basic approaches to computer science notions relevant to molecular computation. (i) State machines; (ii) Boolean networks; (iii) analog computing; (iv) distributed computing. Design Challenge presentation.

Lecture 4. Classical DNA computing

* Adleman experiment
* Maximal clique problem
* SAT problem

Lecture 5: Molecular State machines through self-assembly

* Tiling implementation of state machine
* DNA-based tiling system
* DNA/RNA origami as a spin-off of self-assembling state machines

Lecture 6: Molecular State machines that use DNA-encoded tapes

* Early theoretical work
* Tape extension system
* DNA and enzyme-based finite automata for diagnostic applications

Lecture 7: Introduction to cell-based logic and analog circuits

* Computing with (bio)chemical reaction networks
* Turing computation with ultrasensitivity and cooperativity
* Specific examples

Lecture 8: Transcriptional circuits I

* Introducing transcription-based circuits
* General features and considerations
* Guidelines for large circuit construction

Lecture 9: Transcriptional circuits II

* Large-scale distributed logic circuits in bacteria
* Toward large-scale circuits in mammalian cells

Lecture 10: RNA circuits I

* General principles of RNA-centered circuit design
* Riboswitches and sRNA regulation in bacteria
* Riboswitches in yeast and mammalian cells
* General approach to RNAi-based computing

Lecture 11: RNA circuits II

* RNAi logic circuits
* RNAi-based cell type classifiers
* Hybrid transcriptional/posttranscriptional approaches

Lecture 12: In vitro DNA-based logic circuits

* DNAzyme circuits playing tic-tac-toe against human opponents
* DNA brain

Lecture 13: Advanced topics

* Engineered cellular memory
* Counting and sequential logic
* The role of evolution
* Fail-safe design principles
Lecture notes
Lecture notes will be available online.

Literature
As a way of general introduction, the following two review papers could be useful:


Benenson, Y. Biocomputers: from test tubes to live cells. Molecular Biosystems 2009, 5:675:685

Prerequisites / notice
Basic knowledge of molecular biology is assumed.

636-0107-00L Microbial Biotechnology

Abstract
Students of this course know and can evaluate modern methods of microbial biotechnology and enzyme technology and understand their relation to modern applications of microbial biotechnology.

Objective
Students of this course know and can evaluate modern methods of microbial biotechnology and enzyme technology and understand their relation to modern applications of microbial biotechnology.

Content
The course will cover in its main part selected fundamental and advanced topics and methodologies in microbial molecular biology. Major topics include I) Microbial physiology of microbes (prokaryotes and selected fungi), II) Applications of Microbial Biotechnology, III) Enzymes - advanced kinetics and engineering, IV) Principles of in vivo directed evolution, V) System approaches to cell engineering/metabolic engineering, and VI) Trends in Microbial Biotechnology. The course is a mix of lectures and different exercise formats.

Lecture notes
Notes will be provided in the forms of handouts.

Literature
The course will use selected parts of textbooks and then original scientific publications and reviews.

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Self-direction and Self-management

636-0108-00L Biological Engineering and Biotechnology

Abstract
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content

Lecture notes
Handout during the course.

636-0550-00L Biomolecular Nanotechnology

Abstract
Biomolecular nanotechnology is a broad field that focuses on the study and science of biological materials including DNA, RNA and proteins at length scales below 10 nm. This is a broad overview of the topic with a focus on current research themes.

Objective
The objective is to familiarise the students with a broad range of topics related to biotechnology, nanotechnology, and biophysics with a focus on current research and reading of scientific literature.

Content
Introduction to biomacromolecules; Measurement techniques for characterisation of biomacromolecules; Fundamentals of molecular recognition; Recombinant DNA; Protein engineering; Directed evolution; Protein folding; Polymers; Elastin-like polypeptides; Intelligent materials; Spatially localized hydrogels; Mechanical properties of proteins and macromolecules; Single-molecule force spectroscopy

Literature
 Representative literature:
(1) Alberts, Molecular Biology (Ch.2 Cellular chemistry).
(2) Ratner, Biomaterials Science (Ch. 2.3, 2.4 Polymers & hydrogels).
(3) Walsh, Protein Biochemistry, (Ch. 2, Protein Structure).

636-0109-00L Stem Cells: Biology and Therapeutic Manipulation

Abstract
Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

Objective
Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.
We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:
- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

Fostered competencies

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<td>Self-presentation and Social Influence</td>
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<td>Personal Competencies</td>
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<td>Integrity and Work Ethics</td>
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636-0118-00L Introduction to Dynamical Systems with Applications to Biology

Abstract
Many physical systems are dynamic and are characterized by internal variables that change with time. Describing the quantitative and qualitative features of this change is the topic of dynamical systems theory. Dynamical systems arise naturally in virtually all scientific disciplines including physics, biology, chemistry and engineering. This course is a broad introduction to the topic dynamical systems and the current state of research and novel methodologies in spatial biology, tissue physiology. The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will obtain the necessary toolkit to independently identify open research problems in various areas of spatial biology, to address these problems with suitable experimental strategies, and to formulate their approach in a research proposal.

Objective
The goal of this course is to introduce the student to dynamical systems and to develop a solid understanding of their fundamental properties. The theory will be developed systematically, focusing on analytical methods for low dimensional systems, geometric intuition, and application examples from biology. Computer simulations using matlab will be used to demonstrate various concepts and application examples from biology.

Content
A dynamical view of the world; the importance of nonlinearity; solutions of differential equations; solving equations on the computer; the phase plane; fixed points and stability; linear stability analysis; classifications of linear systems; Liapunov functions and nonlinear stability; cycles and oscillations; bifurcations and bifurcation diagrams. Many biological examples will be used through the course to demonstrate the concepts.

Lecture notes
Will be provided as needed.

Literature

Prerequisites / notice
Prerequisites: Calculus; a first course in differential equations; basic linear algebra (eigenvalues and eigenvectors). Matlab programming.

636-0123-00L Problem-Based Approach to Spatial Biology

Abstract
Does not take place this semester.

Objective
This course entails lectures in tissue physiology, spatial methodologies and grantsmanship. In the project part, small working groups will perform the entire scientific process around formulating a research proposal with the aid of tutors. The students will understand the current state of research and novel methodologies in spatial biology and tissue physiology. They will obtain the necessary toolkit to independently identify open research problems in various areas of spatial biology, to address these problems with suitable experimental strategies, and to formulate their approach in a research proposal.

Content
We will use a problem-based approach to explore the way in which single cells collaborate within tissues to achieve their common functions. A thorough comprehension of these tissue components is crucial for advancing our knowledge of normal homeostasis and pathophysiology; disrupted cellular interactions can lead to decreased tissue function or even carcinogenesis.

The project work will be conducted in small groups in guidance of tutors. Each group will focus on a different topic in spatial biology and will review the corresponding literature. They will identify open problems of interest in this area and will summarize their findings in a short, written review. The students will then develop an appropriate experimental strategy to address a question of interest and write a research proposal that features their approach. The final stage of the project work enable the students to practice the presentation of their research proposals and critical evaluation.

Literature
Will be provided during the course.

Prerequisites / notice
This course requires independent group work.

636-0119-00L Introduction to Statistics and R

Abstract
This course offers a practical introduction to the fundamentals of data analysis and R programming including markdown and data handling with the tidyverse.

Objective
To acquire the statistical understanding to design an appropriate analysis and the practical skills to implement the analysis in R and present the results.

Content
Data analysis is fundamental for arriving at scientific conclusions and testing different hypotheses. This course offers a hands-on introduction to statistical analyses including: exploratory data analysis, testing differences in populations, p-values, power calculations, multiple testing, confounding, linear regression, maximum likelihood, model selection, and logistic regression; along with the fundamentals of R programming including markdown and data handling with the tidyverse.

Lecture notes
Lecture slides will be available

Prerequisites / notice
Access to Rstudio with some markdown and tidyverse packages installed.

636-0017-00L Computational Biology

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.
Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic and phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genelinkages and phylogenies. Lastly, we introduce the field of phenology. With the help of the models and methods presented in this course, students will learn how to extend and apply these methods and algorithms to the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes
Lecture slides will be available on moodle.

Literature
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.
A script with reading material and exercises will be provided by the lecturer. For the lessons on style, students should have the following book:

*Writing Science in Plain English by Anne E. Greene*

ISBN: 9780226026374
Published May 2013 by the University of Chicago Press

### Prerequisites / notice

Students should have a good level of English (B2 level or above) and be ready to write about their own research. This will require having some results to write about, even if they are preliminary.

Students should also bring a laptop computer to each class for the various writing activities we do in class.

### Fostered competencies

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<tr>
<th>Social Competencies</th>
<th>Communication</th>
<th>assessed</th>
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### Transferable Skills

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>Lecturers</td>
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<td>Only for doctoral students.</td>
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<tr>
<td>Abstract</td>
<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Objective</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.</td>
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| 900-0101-DRL| Transferable Skills Course II (1-3 days)        | W    | 1    | 2S    | Lecturers |
|             | Only for doctoral students.                    |      |      |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. |

| 900-0102-DRL| Transferable Skills Course III (1-3 days)       | W    | 1    | 2S    | Lecturers |
|             | Only for doctoral students.                    |      |      |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. |

| 900-0103-DRL| Transferable Skills Course I (1-3 days, with Poster or Talk) | W    | 2    | 4S    | Lecturers |
|             | Only for doctoral students.                    |      |      |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0104-DRL| Transferable Skills Course II (1-3 days, with Poster or Talk) | W    | 2    | 4S    | Lecturers |
|             | Only for doctoral students.                    |      |      |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0105-DRL| Transferable Skills Course III (1-3 days, with Poster or Talk) | W    | 2    | 4S    | Lecturers |
|             | Only for doctoral students.                    |      |      |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0106-DRL| Transferable Skills Course I (min 4 days)       | W    | 2    | 4S    | Lecturers |
|             | Only for doctoral students.                    |      |      |       |           |
| Abstract    | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective   | Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0107-DRL Transferable Skills Course II (min 4 days) W 2 credits 4S Lecturers

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0108-DRL Transferable Skills Course III (min 4 days) W 2 credits 4S Lecturers

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0109-DRL Transferable Skills Course I (min 4 days, with Poster or Talk) W 3 credits 6S Lecturers

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL Transferable Skills Course II (min 4 days, with Poster or Talk) W 3 credits 6S Lecturers

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL Transferable Skills Course III (min 4 days, with Poster or Talk) W 3 credits 6S Lecturers

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year) W 1 credit 2P Lecturers

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.
Member of Executive Board (min 1 year)  W  2 credits  4P  Lecturers

Only for doctoral students.

Abstract
Active participation in the presidency or executive board of a university group for at least 1 year.

Objective
Active participation in the presidency or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

851-0178-00L  Ethics and Scientific Integrity for Doctoral Students  W  1 credit  2U  G. Achermann, E. Bobst, N. Gruber, E. Vayena

This course is interdisciplinary. If your department offers this course, please register there. The following departments offer this course in the fall semester 2022: D-BAUG, D-ERDW, MaP Doctoral School, D-USYS

Doctoral students from D-GESS will have the opportunity to register for a discipline-specific course in spring semester 2023.

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content
Abstract
The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Prerequisites / notice
For doctoral students only.

Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>W</td>
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<td>2K</td>
<td>Lecturers</td>
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</table>

Only for doctoral students.

Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

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<th>Code</th>
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### Objective

Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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<th>Course Code</th>
<th>Course Description</th>
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<th>Type</th>
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<tr>
<td>900-0161-DRL</td>
<td>Summer School III (min 4 days, with Poster or Talk)</td>
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<td>3</td>
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</tbody>
</table>

#### Abstract

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#### Objective

- Participation in summer or winter schools with a minimum duration of 4 days.
- Participants need to present either a poster or a talk at this occasion.

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</thead>
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<tr>
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<td>External Conference I (incl. Poster or Talk)</td>
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</table>

#### Abstract

Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### Objective

- Participation in conferences outside ETH to foster scientific exchange.
- Participants need to present either a poster or a talk at this occasion.

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<th>Course Code</th>
<th>Course Description</th>
<th>Credits</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>900-0163-DRL</td>
<td>External Conference II (incl. Poster or Talk)</td>
<td>W</td>
<td>1</td>
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#### Abstract

Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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#### Objective

- Participation in conferences outside ETH to foster scientific exchange.
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**Doctorate Biosystems Science and Engineering - Key for Type**

<table>
<thead>
<tr>
<th>Letter</th>
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<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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**Key for Hours**

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<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Analytical Competencies
Presentation and discussion of current research topics in analytical chemistry

Adaptability and Flexibility

Analytical Chemistry Seminar
Organic Chemistry
Laser for Micro- and Nanostructuring

Title
Type
ECTS
Hours
Lecturers

Analytical Chemistry Seminar
E-
0 credits
2S
D. Günther

Main Group Element and Coordination Chemistry
E-
0 credits
2S
H. Grützmacher

Inorganic and Organometallic Chemistry
E-
0 credits
2K
C. Copéret, H. Grützmacher, D. Günther, M. Kovalenko, T. Lippert, V. Mougel, P. Steinegger

Laser for Micro- and Nanostructuring
W
2 credits
2V
T. Lippert, N. Shepelin

Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Fostered competencies

Subject-specific Competencies
Concepts and Theories
assessed

Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
not assessed

Decision-making
not assessed

Media and Digital Technologies
not assessed

Problem-solving
assessed

Management
not assessed

Project Management
not assessed

Social Competencies
Communication
not assessed

Cooperation and Teamwork
not assessed

Customer Orientation
not assessed

Leadership and Responsibility
not assessed

Self-presentation and Social Influence
not assessed

Sensitivity to Diversity
not assessed

Negotiation
not assessed

Personal Competencies
Adaptability and Flexibility
not assessed

Creative Thinking
assessed

Critical Thinking
assessed

Integrity and Work Ethics
assessed

Self-awareness and Self-reflection
not assessed

Self-direction and Self-management
not assessed

Organic Chemistry

Title
Type
ECTS
Hours
Lecturers

Analytical Chemistry Seminar
E-
0 credits
1K
R. Zenobi

Organic Chemistry (Seminar)
E-
0 credits
2S
E. M. Carreira, J. W. Bode, H. Wennemers, R. Zenobi

Organic Chemistry
E-
0 credits
1.5K
J. W. Bode, E. M. Carreira, P. Chen, H. Wennemers, R. Zenobi

Cellular Matters: From Milestones to Open Questions
W
4 credits
2S

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 681 of 2416
address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

Abstract
In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

Objective
In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

Content
In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leveres on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

Lecture notes
The presentations will be made available after the lectures.

Literature
For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td></td>
<td>Negotiation</td>
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</tr>
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</table>

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

Lecture notes
The milestone papers will be provided in advance.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 682 of 2416
### Introduction to the Construction of Measurement Devices in Physical Chemistry

**Objective**

Basic concepts of the construction of instrumentation in physical chemistry. Practical exercises in mechanical manufacturing.

**Lecture notes**

Unterlagen in der ersten Stunde verteilt.

**Prerequisites / notice**

Zugang mit Bewilligung des Dozenten.

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### Nuclear Magnetic Resonance Seminar

**Abstract**

Research seminar on current problems in nuclear magnetic resonance spectroscopy.

**Objective**


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### Advanced High Resolution Molecular Spectroscopy

**Abstract**

The course teaches advanced topics in molecular spectroscopy: techniques for analysing rotationally and rovibrationally resolved spectra will be discussed, the basics of FTIR spectroscopy will be reviewed, and the sources which may be used in high resolution infrared spectroscopy will be described. The fields in which high resolution infrared /THz spectroscopy is applied will also be reviewed.

**Objective**

The students will understand how to use the tools needed to analyze simple highly resolved spectra. They will become familiar with experimental techniques in high resolution molecular spectroscopy and will understand how molecular spectroscopy can be applied to solve problems with respect to atmospheric pollutants and the detection of molecules in interstellar space.

**Content**

The students will learn how to record rotationally and rovibrationally resolved spectra in the THz and IR frequency range. For that purpose state-of-the-art sources like synchrotrons, FELs and other THz sources will be discussed. In this context, the basics of Fourier transform infrared spectroscopy will also be reviewed. The analysis of such spectra with interactive programs will then be explained. Finally, applications of high resolution molecular spectroscopy in the field of atmospheric and interstellar chemistry will be discussed. The identification and the quantitative determination of atmospheric pollutants will be discussed in detail. In addition, the identification of interstellar molecules in the context of the origin of life will be reviewed. The question of the identification of the interstellar unidentified infrared bands and of the interstellar diffuse bands will also be addressed. Finally, high resolution molecular spectroscopy of chiral molecules in the context of molecular parity violation will be discussed.

**Literature**

Will be given in the lecture.

---

### Calculating Free Energy Differences from Molecular Simulation: Theory and Practical Applications

**Abstract**

Theoretical analysis as well as issues of practical implementation of state of the art free energy methods.

**Objective**

Recognition of the concepts that underlie the different approaches. Revisited for the determination of free energies. A wide variety of fundamental chemical quantities such as binding or equilibrium constants, solubilities, partition coefficients, and adsorption coefficients are related to the difference in free energy between particular (non)physical states of a system. A maze of computational techniques to calculate free energies is nowadays available that differ in efficiency and accuracy. However, most of them are rooted in a few basic ideas. In the lecture state of the art methods are discussed in light of these basic ideas.

**Lecture notes**

Handouts will be provided.

**Literature**


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### Cellular Matters: From Milestones to Open Questions

**Abstract**

The number of participants is limited to 22 and will only take place with a minimum of 11 participants. Please sign up until two weeks before the beginning of the semester (for Autumn 2022: by 05.09.2022 end of day) via e-mail to bmi@ethz.ch using in the subject: 551-0357-00. In the email body indicate 1) your name, 2) your e-mail address, 3) master/PhD program. The students admitted to this seminar will be informed by e-mail in the week prior to the beginning of the semester.

The first lecture will serve to form groups of students and assign papers.

**Abstract**

In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.
In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise). As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion. With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that levering on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

The presentations will be made available after the lectures.

The milestone papers will be provided in advance.

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#### Chemical and Bioengineering

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<tr>
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<th>Hours</th>
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<tr>
<td>529-0690-00L</td>
<td>ICB Seminars on Chemical and Biochemical Engineering</td>
<td>W</td>
<td>1 credit</td>
<td></td>
<td>P. Arosio</td>
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The discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

Internationally, the milestones on this new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. These discoveries are changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

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Polymer Science

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<tr>
<td>529-0053-00L</td>
<td>Polymer Physics Methods for Unstructured Biomolecules</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Yulikov, G. Jeschke</td>
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</table>

Abstract

The course will provide the "polymer physics view" for the broad area of bio-polymers research. This will include simple and advanced concepts, forming the theoretical "language", critical overview of experimental methods, including the differences in characterization of synthetic and bio-polymers, concepts for modelling conformational ensembles of unstructured bio-polymers.

Objective

From the fundamental education point, this course will systematically overview the power of the thermodynamic description, and the interplay between the energy and the entropy for the phenomena that happen at the edge of near equivalence of the thermal energy and the inter-molecular interaction energy.

Due to complexity of the bio-molecular interactions, the most successful research approaches in the field of unstructured bio-polymers are based on a clever combination of several structural and spectroscopic methods.

Therefore, in this course, there will be a good opportunity to introduce the cross-validation analysis based on complimentary spectroscopic methods, to see examples from real research on different accuracy and different applicability ranges of experimental methods, and to discuss how very different spectroscopic data types can be combined to enhance the understanding of a bio-polymer system.
- Overview of unstructured bio-polymers and bio-polymers with unstructured domains.

- Overview of bio-molecular interactions and interactions to the solvent molecules: types of interactions, energy scales, time scales, length scales.

- Overview of spectroscopic methods to characterize the overall conformational properties of unstructured bio-polymers, the strength of their interactions, the peculiarities of their interactions at the atomic level (fluorescence methods, magnetic resonance methods, scattering methods, cross linking methods).

- Comparison of these methods in respect to their applicability range, sensitivity range, accuracy, type of the data.

- Thermodynamic concepts of bio-polymers, existing models for energy and entropy contributions: Flory theory for polymer chain conformational distribution, reversible gelation theory, electrochemical solvent effects, isotope effects, entropic effects for inhomogeneous distribution of interacting moieties over the polymer chain.

- Topics on nucleic acids: double helix vs. single strand stability, conformational ensembles, solvent interactions.

- Topics on unstructured proteins and protein domains: entropy contributions, reversible folding, crowding effects, liquid-liquid phase separation, RNA interactions, entropic terms in protein crystallization, entropic terms in reaction constants of interfering binding sites.

- Topics of polymer physics of carbohydrates.

- Site directed labeling of weakly interacting unstructured bio-molecules, disturbances, selection of reference states, interpretation of the data.

- Hybrid methods in studies of bio-polymers, their strength and challenges: accuracy and information content of different methods, ways to combine them, ways to model the bio-polymers based on hybrid spectroscopic data, ways to describe the broad conformational ensembles.

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### Pharmaceutical Sciences

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<tr>
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<td>535-2000-00L</td>
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<td>G. Schneider</td>
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<td>535-0910-00L</td>
<td>From A to Z in Drug Discovery and Development</td>
<td>Z</td>
<td>1 credit</td>
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<td>J. Hall, K.-H. Altmann, M. Arand, J. Scheuermann, R. Schibli, H. U. Zeilhofer</td>
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### Additional Courses

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<td>529-0195-00L</td>
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**Transferable Skills**

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<tr>
<td>900-0111-DRL</td>
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Integration into Scientific Community

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Autumn Semester 2022
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<tr>
<td>Abstract</td>
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<td>900-0161-DRL</td>
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<td>Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.</td>
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</table>
Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**External Conference II (incl. Poster or Talk)**

*Only for doctoral students.*

**Abstract** Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Objective** Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**900-0163-DRL** 1 credit 2K Lecturers

**External Conference III (incl. Poster or Talk)**

*Only for doctoral students.*

**Abstract** Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Objective** Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Doctorate Chemistry and Applied Biosciences - Key for Type**

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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Courses outside the curriculum</td>
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**Key for Hours**

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<td>P</td>
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<td>D</td>
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<td>R</td>
<td>revision course / private study</td>
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**ECTS** European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Subject Specialisation

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<tr>
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<td>651-4931-00L</td>
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<td>651-1180-00L</td>
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<td>W. Behr</td>
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<td>Geophysical Fluid Dynamics and Numerical Modelling Seminar</td>
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<td>P. Tackley, T. Gerya</td>
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### Transferable Skills

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</table>
900-0104-DRL  Transferable Skills Course II (1-3 days, with Poster or Talk)  W  2 credits  4S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective  Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0105-DRL  Transferable Skills Course III (1-3 days, with Poster or Talk)  W  2 credits  4S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective  Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0106-DRL  Transferable Skills Course I (min 4 days)  W  2 credits  4S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0107-DRL  Transferable Skills Course II (min 4 days)  W  2 credits  4S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0108-DRL  Transferable Skills Course III (min 4 days)  W  2 credits  4S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

Objective  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

900-0109-DRL  Transferable Skills Course I (min 4 days, with Poster or Talk)  W  3 credits  6S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL  Transferable Skills Course II (min 4 days, with Poster or Talk)  W  3 credits  6S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective  Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL  Transferable Skills Course III (min 4 days, with Poster or Talk)  W  3 credits  6S  Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL Participation in Commission I (min 1 year)
W 1 credit 2P Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year)
W 1 credit 2P Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year)
W 2 credits 4P Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

651-6001-00L Ethics and Scientific Integrity for Doctoral Students of D-ERDW
W+ 1 credit 2S T. I. Eglinton, H. Stoll

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a discipline-specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content
Part I
The self-paced e-learning course consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making desicions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For Doctoral Students of D-ERDW only

Fostered competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Problem-solving</td>
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<td>Personal Competencies</td>
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<td>Integrity and Work Ethics</td>
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Language Courses ETH/UZH: see Science in Perspective
Educational Science for Teaching Diploma and TC

Integration into Scientific Community

Number  Title                          Type  ECTS  Hours  Lecturers
900-0150-DRL  Summer School I (1-3 days)  W 1 credit 2K Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer
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<td>900-0159-DRL</td>
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</table>
Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0160-DRL Summer School II (min 4 days, with Poster or Talk)  W  3 credits  6K Lecturers

Only for doctoral students.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0161-DRL Summer School III (min 4 days, with Poster or Talk)  W  3 credits  6K Lecturers

Only for doctoral students.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0162-DRL External Conference I (incl. Poster or Talk)  W  1 credit  2K Lecturers

Only for doctoral students.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0163-DRL External Conference II (incl. Poster or Talk)  W  1 credit  2K Lecturers

Only for doctoral students.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0164-DRL External Conference III (incl. Poster or Talk)  W  1 credit  2K Lecturers

Only for doctoral students.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
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Doctorate Earth Sciences - Key for Type

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<td>Recommended, not eligible for credits</td>
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Key for Hours

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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Subject Specialisation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0587-01L</td>
<td>CIS PhD Colloquium</td>
<td>W</td>
<td>2 credits</td>
<td>2K</td>
<td>University lecturers</td>
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<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: 615G932C</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>In this internal colloquium doctoral students present their work after about 12 months of research.</td>
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<td>Objective</td>
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<td></td>
<td>The aim of this colloquium is that the presenters receive feedback on their research at an important stage (a stage at which significant changes of direction, methodology, etc., may still be undertaken) in the PhD process.</td>
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<td>Content</td>
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<td></td>
<td>Presentation of doctoral research.</td>
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<td>Lecture notes</td>
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<td>Distributed electronically.</td>
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<td>Prerequisites / notice</td>
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<td>Dates: See <a href="http://www.cis.ethz.ch/education/index">http://www.cis.ethz.ch/education/index</a></td>
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<tr>
<td>851-0626-02L</td>
<td>PhD Colloquium in Development Economics</td>
<td>W</td>
<td>1 credit</td>
<td>1K</td>
<td>I. Günther</td>
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<td>Does not take place this semester.</td>
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<td>PhD students working in empirical development economics will present their ongoing work, with a particular focus on the methods (to be) used and challenges faced. Participants are expected to read the drafts/papers/presentations beforehand and give constructive feedback to the PhD student presenting.</td>
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<td></td>
<td>PhD students learn how to present and discuss their own research questions, methods, results and problems. PhD students get familiar with the challenges of empirical economics research in low income countries.</td>
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<td>Prerequisites / notice</td>
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<td>This is a two days course.</td>
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<tr>
<td>851-0735-10L</td>
<td>Law for Entrepreneurs</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>P. Peyrot</td>
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<td></td>
<td>Number of participants limited to 100</td>
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<td>Particularly suitable for students of D-ITET, D-MAVT</td>
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<td>Abstract</td>
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<td></td>
<td>The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.</td>
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<td>The students shall obtain the following competence:</td>
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<td>- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.</td>
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<td>- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution</td>
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<td>- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.</td>
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<td>- They shall be able to contribute to the legal management of the company and to discuss legal issues.</td>
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<td>- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.</td>
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<td>Lecture notes</td>
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<td>A comprehensive script will be made available online on the moodle platform.</td>
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<tr>
<td>851-0733-09L</td>
<td>Workshop &amp; Lecture Series on the Law &amp; Economics of Innovation</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>S. Bechtold</td>
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<td>Does not take place this semester.</td>
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<td>This series is a joint project by ETH Zurich and the Universities of St. Gallen and Zurich. It provides an overview of interdisciplinary research on intellectual property, innovation, antitrust, privacy &amp; technology policy. Scholars from law, economics, management and related fields present their current research. All speakers are internationally well-known experts from Europe, the U.S. &amp; beyond.</td>
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<td>After the workshop and lecture series, participants should be acquainted with interdisciplinary approaches towards intellectual property, innovation, antitrust, privacy and technology policy research. They should also have an overview of current topics of international research in these areas.</td>
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<td>Content</td>
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<td>The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.</td>
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<td>Lecture notes</td>
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<td>Papers discussed in the workshop and lecture series are posted in advance on the course web page.</td>
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<td>Literature</td>
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<td></td>
<td>Suzanne Scotchmer, Innovation and Incentives, 2004</td>
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<td></td>
<td>Bronwyn Hall / Nathan Rosenberg (eds.), Handbook of the Economics of Innovation, 2 volumes, Amsterdam 2010</td>
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<td>Bronwyn Hall / Dietmar Harhoff, Recent Research on the Economics of Patents, 2011</td>
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<td></td>
<td>Fostered competencies</td>
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<td>Subject-specific Competencies</td>
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<td>Method-specific Competencies</td>
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<td>Social Competencies</td>
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<td>Personal Competencies</td>
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<td></td>
<td>Concepts and Theories</td>
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<td>Analytical Competencies</td>
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<td>Problem-solving</td>
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<td>Communication</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
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<tr>
<td>851-0738-00L</td>
<td>Intellectual Property: Introduction</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Schweizer</td>
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<td></td>
<td>Particularly suitable for students of D-CHAB, D-INFOK, D-ITET, D-MAVT, D-MATL, D-MTEC</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.</td>
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</table>
Objective
The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector

Abstract
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Objective
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

Prerequisites / notice
The lecture addresses students in the fields of engineering, science and other related technical fields.

Prerequisite: Participants should be involved in research and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and the focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with the fundamentals of cognitive, behavioral and social science. After that, each work group chooses an aspect of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). Students will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

851-0252-04L Behavioral Studies Colloquium

Abstract
This colloquium offers an opportunity to discuss recent and ongoing research and scientific ideas in the behavioral sciences, both at the micro- and macro-levels of cognitive, behavioral and social science. The colloquium features invited presentations from both internal and external researchers as well as presentations of doctoral students close to submitting their dissertation research plan.

Objective
Participants are informed about recent and ongoing research in different branches of the behavioral sciences. Presenting doctoral students obtain feedback on their dissertation research plan.

Content
This colloquium offers an opportunity to discuss recent and ongoing research and scientific ideas in the behavioral sciences, both at the micro- and macro-levels of cognitive, behavioral and social science. It covers a broad range of areas, including theoretical as well as empirical research in social psychology, research on higher education, sociology, modeling and simulation in sociology, decision theory and behavioral game theory, economics, research on learning and instruction, cognitive psychology and cognitive science.

The colloquium features invited presentations from internal and external researchers as well as presentations of doctoral students close to submitting their dissertation research plan.

851-0252-01L Human-Computer Interaction: Cognition and Usability

Abstract
This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.

Objective
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

851-0252-05L Research Seminar Cognitive Science

Abstract
The colloquium provides a forum for researchers and graduate students in cognitive science to present/discuss their ongoing projects as well as jointly discuss current publications in cognitive science and related fields. A subset of the sessions will include invited external visitors presenting their research. Participants of this colloquium are expected to be involved in active research group.

Objective
Graduate student train and improve their presentation skills based on their own project ideas, all participants stay informed on current trends in the field and have the opportunity for networking with invited scholars.
Computational Social Science

Number of participants limited to 40.

Abstract
The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g., sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work. Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

Objective
They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e., an interdisciplinary integration of knowledge.

Literature
Computational Social Science
https://science.sciencemag.org/content/sci/323/5915/721.full.pdf

Manifesto of Computational Social Science
https://link.springer.com/article/10.1140/epjst/e2012-01697-8

Social Self-Organisation

How simple rules determine pedestrian behaviour and crowd disasters
https://www.pnas.org/content/108/17/6884.short

Peer review and competition in the Art Exhibition Game
https://www.pnas.org/content/113/30/8414.short

Generalized network dismantling
https://www.pnas.org/content/116/14/6554.short

Computational Social Science: Obstacles and Opportunities
https://science.sciencemag.org/content/369/6507/1060?rss%3D1=

Bit by Bit: Social Research in the Digital Age
https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFXX2/

Further literature will be recommended in the lectures.

Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Governing the Energy Transition

Does not take place this semester.
Primarily suited for Master and PhD level.

Abstract
This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.

Objective
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions
- To gain knowledge on the role of policy and politics in energy transitions
This lecture will discuss important topics of the Arab culture involving concepts relating to history, the role of literature, sciences and religion, concepts of 'the West', meaning of education, understanding of culture as well as current concepts and discourses relevant at the sociocultural level.

Teaching about epistemic contents relating to the Arab world that constitute modern Arabs' self understanding and are relevant for adequate behavior in practically dealing with the Arab world. What basic knowledge about 'their' culture are Arabs taught? What educational goals are pursued? What is the relationship they build with the West?

The topics that are discussed on the basis of a scientifically critical approach are concepts and understandings of history, the role of literature, sciences and religion, concepts of the West and relationship with the West, the role of education, understanding of culture and cultural refinement, current concepts and discourses relevant at the sociocultural level.

This seminar will study cognitive processes, behavior and the underlying biological response to financial decisions. Research methods such as asset market experiments, lottery games, risk preference assessment, psychometrics, neuroimaging and psychophysiology of decision processes will be discussed. Financial bubbles and crashes will be the core interest.

This course has four main goals:
1. To learn about the most important topics within Behavioural Finance
2. To learn how to conduct behavioural studies, design experiments, plan data collection and experimental tasks
3. To learn about causes of market crashes, factors that influence them, traders' behaviour before, during and after financial crises
4. To investigate a topic of interest, related to behaviour of traders during market crashes.

Additionally, the course gives to the students the opportunity to practice oral presentations, communication skills, report writing and critical thinking.

The course provides an overview of the most important topics in Behavioural Finance. First part of the course involves reading scientific articles, which will be discussed during the seminar. Therefore, attendance is required to pass the course. Each week, a student volunteer will present a paper and the presentation will be followed by a discussion. After obtaining sufficient knowledge of the field, students will select a topic for a behavioural study of their own. The final assignment consists of preparing and conducting a small behavioural study/experiment, analysing the data and presenting the project in the final meeting of the class. Each student will write a scientific report of their study.

The lecture takes place if a minimum of 12 students register for it.

This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

The seminar covers the following topics:
1. Theories and concepts of inter- and transdisciplinary research
2. The specific challenges of inter- and transdisciplinary research
3. Collaborating between different disciplines
4. Engaging with stakeholders
5. 10 steps to make participants' research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

The lecture takes place if a minimum of 12 students register for it.

This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derivs the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants' research projects more societally relevant.

The following open access article builds a core element of the course:

(5) 10 steps to make participants' research projects more societally relevant

(3) Collaborating between different disciplines

(2) The specific challenges of inter- and transdisciplinary research

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

The lecture takes place if a minimum of 12 students register for it.

This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derivs the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.
Students are required to have basic knowledge in inferential statistics, such as regression models.

Abstract

Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective

Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and tests those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and develop an understanding of how those can be fit to empirical data. This will enable students to independently address research questions from various social science fields.

Content

The following topics will be covered:

- Introduction to network models and their applications
- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models
- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)
  * Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes

Slides and lecture notes are distributed via the associated course moodle.

Literature


Prerequisites

Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

**851-0252-15L Network Analysis**

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<tr>
<td>Particularly suitable for students of D-INFK, D-MATH</td>
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<tr>
<td>Abstract</td>
<td>Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.</td>
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<tr>
<td>Objective</td>
<td>Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.</td>
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<tr>
<td>Content</td>
<td>The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes are distributed via the associated course moodle.</td>
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**851-0742-00L Contract Design I**

This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Contract Design I (851-0742-00L; Fall 2022)" and enroll. The password is "ContractDesign01".

Number of participants limited to 160.
Abstract
Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Objective
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Lecture notes
Handouts, prerecorded videos, slides, and other materials

Prerequisites / notice
Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

Prerequisites: Basic programming skills, elementary probability and statistics.

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

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Autumn Semester 2022
Page 702 of 2416
Students are expected to implement models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

The lecture slides will be presented on the course web page after each lecture.

Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Particularly suitable for students of D-ARCH

The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

Applied Network Science: Social Media Networks

Number of participants limited to 20

We study applications of network science methods, this semester in the domain of social media. Topics are selected for diversity in research questions and techniques for topics such as privacy and information spread on a variety of platforms. Student teams present results from the recent literature, possibly with replication, in a one-day conference.
Objective
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on social media, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

851-0253-07L Consciousness Studies
Number of participants limited to 80.

Abstract
Covers research on levels and states of consciousness. Levels: conscious vs. pre-/sub-/nonconscious. States: ordinary (OSC, waking consciousness) vs. altered states of consciousness (ASCs, e.g., sleeping/dreaming, hypnosis, meditation, pharmacologically altered state). Applications in health/clinical psychology, and implications for the scientific mind (insight, flow) are also considered.

Objective
To introduce students to the basics of consciousness studies, and to thus help them to gain a deeper understanding of how the mind works. Includes practical implications for the scientific mind.

Content
The study of consciousness involves scholars from diverse fields, such as psychology, neuroscience, cognitive science, philosophy, linguistics, computer science, medicine, religious studies, anthropology, as well as literature and art studies. While the study of consciousness is presented mainly from the point of view of psychology in this course, additional interdisciplinary viewpoints are also integrated.

Psychological consciousness studies involve research on levels and states of consciousness. Psychologically researched levels of consciousness are the conscious, preconscious, unconscious/subconscious, and nonconscious levels of mental processing. Psychological research on states of consciousness – which is the main focus of this course – takes waking consciousness as the most common state (ordinary state of consciousness, OSC), using it as a baseline against which altered states of consciousness (ASCs) are compared. Some of the most prominently or promising researched ASCs in psychology will be introduced in this course and include sleeping/dreaming, hypnosis, meditation, sensory deprivation (e.g., floating tank), rhythm-induced trance, as well as ASCs induced by psychoactive drugs (classic psychedelics, dissociative anesthetics, empathogens). Furthermore, it will also be shown how a growing number of health and clinical studies investigate the therapeutic potential of being temporarily in an ASC. Finally, in this course, two mental phenomena that are also highly relevant for the scientific mind – insight and flow – are also introduced from a consciousness-studies perspective.

851-0253-07L Ethics Workshop: The Impact of Digital Life on Society
Number of participants limited to 40.

Abstract
Open to all Master level / PhD students.

Objective
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.

Content
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork not assessed
- Self-presentation and Social Influence not assessed
- Negotiation assessed

Personal Competencies
- Creative Thinking not assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed

851-0253-07L Building a Robot Judge: Data Science for Decision-Making
Particularly suitable for students of D-INFK, D-ITET, D-MTEC

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

### Building a Robot Judge: Data Science for Decision-Making (Course Project)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
<th>Prerequisites</th>
<th>Objective</th>
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</thead>
<tbody>
<tr>
<td>851-0761-00L</td>
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<td>W 2 credits 2V</td>
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</table>

Please register only if attending the lecture course or with consent of the instructor.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
<th>Prerequisites</th>
<th>Objective</th>
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<tbody>
<tr>
<td>851-0742-01L</td>
<td>Contract Design II</td>
<td>W 1 credit 1U</td>
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</table>

Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

### Medieval and Early Modern Science and Philosophy

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<th>Credit Hours</th>
<th>Prerequisites</th>
<th>Objective</th>
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<tbody>
<tr>
<td>851-0197-00L</td>
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<td>W 3 credits 2V</td>
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</table>

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

### Introduction to Methods in Learning Sciences II

<table>
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<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
<th>Prerequisites</th>
<th>Objective</th>
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<tbody>
<tr>
<td>851-0255-00L</td>
<td></td>
<td>W 2 credits 2S</td>
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</tbody>
</table>

Participation in the introductory version of this course (851-0252-14L Introduction to Methods in Learning Sciences) should be helpful, but not necessary. The class will be designed to allow students with strong STEM backgrounds to catch up and fully participate.

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**Prerequisites / notice**

- Some programming experience in Python is required, and some experience with text mining is highly recommended.
- Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

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**Abstract**

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

**Objective**

There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer’s Teaching Assistant Diego Caldera (diegoalberto.calderaherrera@uzh.ch).

**Prerequisites / notice**

- To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

---

**Prerequisites / notice**

- To be considered for Contract Design II, you must have completed Contract Design I in the same semester.
- Does not take place this semester.

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**Abstract**

The course analyses the evolution of the relation between science and philosophy during the Middle Age and the Early Modern Period.

**Objective**

- to develop a critical understanding of scientific notions;
- to introduce students to the philosophical dimension of science;
- to develop a critical understanding of scientific notions;
- to acquire skills in order to read and comment on scientific texts written in the past ages.

**Content**

The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.

---

**Abstract**

The course aims at equipping students with a suite of advanced quantitative and qualitative tools to support their existing research and develop new lines of inquiry in the Learning Sciences. By providing opportunities to analyze empirical educational data, the course will allow students to develop an appreciation for the breadth of methods that can be employed to improve the process of learning

**Objective**

The course will be centered around exploring methodological perspectives by focusing on conceptual aspects of datasets and experiments in the Learning Sciences. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, performing data analysis, finding patterns in data and linking them to educational theory)

**Content**

The course has the following components: a) advanced statistical methods (e.g., mediation and moderation), b) advanced qualitative methods (e.g., interaction analysis), c) computational methods (e.g., prediction and structured discovery with educational data)

**Prerequisites / notice**

- Participation in the introductory version of this course (851-0252-14L Introduction to Methods in Learning Sciences) should be helpful, but not necessary. The class will be designed to allow students with strong STEM backgrounds to catch up and fully participate.
Students are expected to become competent in understanding cognitive, embodied, and social perspectives on learning and learning assessed, T. Sinha, T. Sinha

Cognitive Science views human cognition as information processing and provides an inter-disciplinary integration of approaches from thereon.

There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in

Adaptability and Flexibility

I. Günther

Life and Death

The lectures provide an overview of the foundations of cognitive science and investigate processes of human cognition, especially

Analytical Competencies

Communication

Cooperation and Teamwork

Leadership and Responsibility

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Future Learning Initiative Colloquium

This colloquium offers an opportunity for students to discuss their ongoing research and scientific ideas in the learning sciences. This

Future Learning Initiative projects include productive failure and preparation for future learning, neural basis of learning, mixed reality environments, physical spaces and learning, interdisciplinarity in life sciences education, embodied learning and gaming, abstract

Techniques and Technologies

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The meaning of the "beautiful" seems hard to define. At first glance, it rather constitutes a merely subjective sensation. Yet, on the other hand, this debate was significantly altered. This new "science" aimed at a scientific investigation of the beautiful by situating sensuous experience in a broader context.

For MAGPW and PhD students of D-GESS only.

Languages: German and English

Does not take place this semester.

Does not take place this semester.

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment for the respective module at UZH. Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-students-university-of-zurich.html

Abstract The fortnightly colloquium provides an ideal forum for Master and PhD students as well as postdoctoral researchers to familiarize themselves with current trends in global history. The slots are reserved for presentations by invited external scholars of the highest calibre.

Objective Participants will have an opportunity to follow high level debates in global history. By writing short reports and comments on two selected sessions they train the ability to summarize complex arguments and articulate their position in controversial debates.

Prerequisites / notice Information about dates and program: http://www.gmw.ethz.ch/studium.html

862-0088-11L Research Colloquium Science Studies (HS 2022)  W  2 credits  1K  M. Wagner

Abstract This colloquium is devoted to the introduction into the theory and practice of scientific work. The schedule can be found on the institute's website - http://www.wiss.ethz.ch/en/teaching/

Objective This colloquium is devoted to the introduction into the theory and practice of scientific work.

Prerequisites / notice Lectures may be held either in English or German. Students receive 2 credit points for submitting a brief, written commentary on one of the presented topics (approx. 5 pages).

862-0089-11L Advanced Colloquium in Literary Studies (HS 2022)  W  2 credits  1K  A. Kilcher

Abstract The colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.

Objective The colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.


Abstract The lecture offers a survey of the historical trajectories taken by the countries of the Indian subcontinent from the 17th century to the turn of the 21st century. The thematic focus includes, but are not limited, to an examination of the question whether or not there was a pre-European South Asian modernity.

Objective Through this course students are acquainted with the history of one of the most important world regions. The objective is not only to introduce participants to a richly diverse civilization, they are also encouraged to look at interrelations and make comparisons with the West. Through this approach their knowledge of European history is contextualised in a global framework while simultaneously their intercultural sensitivity is being trained.

851-0184-00L Pluralist Philosophy of Mathematics  W  3 credits  2V  R. Wagner

Abstract This course will follow Michèle Friend's book "pluralism in mathematics". It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.

Objective The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.

Content The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralist and paraconsistent philosophical approaches.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Theoretical Knowledge assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking assessed</td>
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</tbody>
</table>

851-0652-00L Make Your Own Short Film about Global Development  W  0.5 credits  1S  A. Rom

Abstract In this workshop, students will learn how to create a short film about their research related to global sustainable development using their smartphones. They will also reflect on the power of films to reproduce or break stereotypes and prejudices in global development. Short theoretical inputs will be combined with practical work on students’ own video projects.

Objective Students know how to tell an interesting story about their research and how to shoot and cut a short movie using conventional smartphones and laptops.

Content Students know strategies to ensure that the stories they tell do not reproduce stereotypes.

Prerequisites / notice

- To participate in the course, students have to bring their own smartphone and need access to a video editing software on their devices.
- Preference is given to doctoral students working on issues related to global development.

851-0298-00L The Modern Literary and Artistic Avantgarde in its European Dimension  W  3 credits  2V  S. S. Leuenberger

Abstract The modernist Avant-Garde movements are characterized by a radical rhetoric of apocalypse and rebirth, the genesis of another world and a new mankind. The extension of the “intrinsic logic of the aesthetic form into the social fabric” (H. Ehrlicher), and likewise the intensive examination of the latest technical advancements, new forms of media and their combination, unites them.
Objective

Avant-garde movements are characterized by progressive notions on art, social and political issues as well as by radical criticism on the current circumstances. This is why the specific characteristics of the historic avant-garde of the early 20th century will be a central theme of this lecture; they cannot be separated from the experience of modernity, of the catastrophic course of the First World War, and of the concept of new models of society whose political implementation is a major goal after the end of the war.

The lecture is part of the ‘Science in Perspective’ course programme aimed at enabling the students to deal with avant-garde texts and artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter Bürger’s assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-criticism".

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic perspective: literary texts and manifestes by Heym, van Hoddis, Werfel, Lasker-Schüler, Ball, Hulsenbeck, Toller, Marinetti, Ball, Tzara, Huelsenbeck, Hausmann, Apollinaire, Breton, Goll, others will be read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist Avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of technological innovations; second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and, following the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking resilience to totalitarian ideologies.

851-0435-00L Science and Neoliberalism: From the Critique of Planning to Competition and Think Tanks (1950–2000)  W  3 credits  2S  M. Wulz

Abstract

From its beginning, the history of neoliberal thought has been linked to debates about the status of knowledge in society. In the seminar, students learn to understand fundamental debates in the theory of science in their political and economic contexts; moreover, we explore to what extent neoliberal thinkers actually shaped specific forms of science policy and research funding in the 20th century.

Objective

The seminar promotes an understanding of seminal texts in the early philosophy of science (M. Polanyi, J.D. Bernal, etc.) in the context of ideological struggles in the 1930s and 1940s and of the debates about knowledge, science, and society at that time. Moreover, it provides insights into the political and economic foundations of funding policies for education, science, and research that were developed since the 1970s.

Content

Neoliberalism is considered one of the most influential economic currents since the last decades of the 20th century. However, neoliberalism not only has a much longer history, going back to the ideological struggles of the 1930s. Since then, it has also been closely linked to debates about the status of knowledge and science in society. Theorists of science, such as Michael Polanyi, were part of neoliberal discussion circles; economists, such as Friedrich Hayek, developed decentralized forms of knowledge as part of market processes. In this way, they criticized the contemporary demand for economic planning and the idea of science serving social needs. Competition and the market were subsequently regarded as the important driving forces for scientific and economic innovation.

Literature

– Philip Mirowski, Dieter Piehwe (Hg.): The Road from Mont-Pélerin. The Making of the Neoliberal Thought Collective. Harvvard 2009.

851-0527-00L Introduction to the History of Technology: Concepts, W  3 credits  2S  D. Gugeri and Current Debates

Abstract

Technology and society cannot be separated: No society functions without technology. The seminar offers a problem-oriented introduction to basic questions of the history of technology, introduces approaches to the history of technology and discusses selected, ongoing debates.

Objective

The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.

Content

History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

Prerequisites / notice

Beginn 2. Semesterwoche (27.9.2022)

851-0516-05L Mobility and the Border: Migration and Control between Mexico and the USA, 19th–21st Century  W  3 credits  2S  S. M. Scheuzger

Abstract

The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

Objective

A) The students know relevant approaches of the studies of migration, they are able to assess the analytical capacities of these approaches and they know how to apply them to concrete events and processes.
B) The students have acquired knowledge about important aspects of the history of migration between Mexico and the United States.
C) The students are able to identify relevant relations between scientific and technological change on the one hand and developments of migration and its control on the other.

Content

The land border between Mexico and the United States, where the ‘global North’ and the ‘global South’ meet in the most prominent form worldwide, provides an exemplary case to study how borders generate spaces of agency, constitute human communities and create identities – not only by separating people but also by connecting them. The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

880-0100-00L Doctoral Colloquium in Public Policy  W  1 credit  1K  M. Krauser, T. Bernauer, R. Garrett, T. Schmidt, B. Steffen

Abstract

In this colloquium, doctoral students present their research plan within the first year of their doctorate, which is reviewed by three professors affiliated with the ISTP and commented on by the peer students registered in the colloquium. We recommend attending the colloquium for two semesters and present the research plan in the second semester.

Objective

Obtain feedback on research ideas the doctoral research plan and have the research plan approved by three faculty, as required by ETH Zurich.
Understand the philosophical underpinnings of language-based artificial intelligence.

The digital transformation profoundly impacts humans and how they behave online and offline. Interactions in online social networks offer new opportunities (e.g., political movements, communication) and risks (e.g., fake news, mental health risks). In this seminar, we examine sociological and psychological research on how the digital transformation affects individuals and their (social) behavior.

By the end of this seminar, students will be able to identify and compare different approaches in (online) social network research. They will be familiar with recent publications in the fields of social networks and computational social science and be able to critically participate in a number of open debates in these fields. Among others, these debates are centered around the types and measurement of social behavior in online and offline settings, ethical challenges in conducting social networks research, the effects of the digital transformation on people’s feelings, thoughts, and behaviors (e.g., digital mental health), and how online social phenomena emerge (e.g., political movements).

Learning Objectives:
- Know the most relevant social network terminology and concept
- Know the most relevant sociological and psychological social network theories
- Know the most relevant methods to study online and offline behavior
- Be able to develop meaningful social networks research questions
- Be able to design your own social networks study
- Critically examine empirical research in the field of (online) social networks

Content
The digital transformation has made the “online world” increasingly important for the “offline world”. Hence, interactions in online social networks ultimately affect how people feel, think, behave and interact in offline settings. This course aims to present and structure open debates in social network research with a focus on online social networks research, the effects of the digital transformation on people’s feelings, thoughts, and behaviors (e.g., digital mental health), and how online social phenomena emerge as emerging from interrelated social behavior.

Learning Objectives:
1. To acquire a general idea of the history of mathematics until 17th century;
2. To develop a critical understanding of mathematical notions;
3. To have a general idea of the history of mathematics until 17th century;
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<td>Abstract</td>
<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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<td>Objective</td>
<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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<tr>
<td>900-0113-DRL</td>
<td>Participation in Commission II (min 1 year)</td>
<td>1</td>
<td>W</td>
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<td></td>
<td>Only for doctoral students.</td>
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<td></td>
<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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<tr>
<td>Objective</td>
<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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<tr>
<td>900-0114-DRL</td>
<td>Member of Executive Board (min 1 year)</td>
<td>2</td>
<td>W</td>
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<td>Only for doctoral students.</td>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
<td>Active participation in the presidium or executive board of a university group for at least 1 year.</td>
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<tr>
<td>Objective</td>
<td>Active participation in the presidium or executive board of a university group for at least 1 year.</td>
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</tbody>
</table>

### Language Courses ETH/UZH: see Science in Perspective

#### Educational Science for Teaching Diploma and TC

- **851-0178-00L** Ethics and Scientific Integrity for Doctoral Students
  - **W** 1 credit 2U
  - G. Achermann, E. Bobst, N. Gruber, E. Vayena

*This course is interdisciplinary. If your department offers this course, please register there. The following departments offer this course in the fall semester 2022: D-BAUG, D-ERDW, MaP Doctoral School, D-USYS*
Doctoral students from D-GESS will have the opportunity to register for a discipline-specific course in spring semester 2023.

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply and deepen their knowledge in an interactive face-to-face workshop.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content
Content:

Part I on Moodle
The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II).

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

Fostered competencies

Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Decision-making
- Problem-solving

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics

851-0093-00L Ethical Issues in the Economy
Doctoral students can receive credit for the achievements of this course in the section "Transferable Skills".

Abstract
Ecological crises and growing social inequalities rise the urgent question: Is the global way we are doing economics reasonable? – Which kind of wealth is illegitimate? Is a policy of de-growth needed for protecting our ecological niche? Will technological devices e.g. AI-driven market designs for public goods be the solution or is a change of attitudes necessary to cope with such problems?

Objective
Participants should learn to know and being enabled to evaluate answers to the following questions:
1. To which extent are economic success and wealth something deserved, and to which extent are they the outcome of lucky circumstances or favorable conditions? And what follows from the answer for the judgment on social inequalities?
2. How much consumption and growth are enough?
3. Which commons should not be privatized?
4. What should entrepreneurs and consumers be responsible for?
5. Does a sharing economy promote a responsible way of doing business?
6. Are technologies for regulating production and allocation of resources as well as regulating consumption of goods apt to cope with problems of social inequality, of protecting our ecological niche, and do they empower producers, investors and consumers to act responsible?
7. What are the good things and what are the bad things about the global capitalist scheme doing business in the 21st century?
8. Do we need a de-globalization of doing economics?

851-0092-00L Artificial vs Human?
Die Doktorierenden können sich die Leistung dieses Kurses im Bereich "überfachliche Kompetenzen" anrechnen lassen.

Abstract
KI-based machines and artificial agents are playing more and more a crucial role in our social and political life. Do they essentially differ from human intelligence and human actors or are they merely an (advanced) version of us? How should we judge on their role? For answering such questions one has to give an account of essential features of intelligence, reason, and agency.

Objective
Participants should learn to know some philosophical accounts of intelligence, reason, and agency. This knowledge should enable them to evaluate the pro and con of answers to questions of the following kind:
1. Is human deliberation and argumentation essentially algorithmic?
2. Is AI confined to smart solutions of given problems or is AI also able to revise the framing of problems?
3. Could artificial agents like robots be responsible for their behavior?
4. Do my smartphone and I constitute an extended, hybrid mind?
5. How should we deal with AI-based machines in our social and political life?

Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0150-DRL</td>
<td>Summer School I (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2K</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 713 of 2416
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### 900-0151-DRL Summer School II (1-3 days)

- **Only for doctoral students.**
- **W** 1 credit
- **Lecturers**

Abstract: Participation in summer or winter schools with a maximum duration of 3 days.

Objective: Participation in summer or winter schools with a maximum duration of 3 days.

### 900-0152-DRL Summer School III (1-3 days)

- **Only for doctoral students.**
- **W** 1 credit
- **Lecturers**

Abstract: Participation in summer or winter schools with a maximum duration of 3 days.

Objective: Participation in summer or winter schools with a maximum duration of 3 days.

### 900-0153-DRL Summer School I (1-3 days, with Poster or Talk)

- **Only for doctoral students.**
- **W** 2 credits
- **4K Lecturers**

Abstract: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

### 900-0154-DRL Summer School II (1-3 days, with Poster or Talk)

- **Only for doctoral students.**
- **W** 2 credits
- **4K Lecturers**

Abstract: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

### 900-0155-DRL Summer School III (1-3 days, with Poster or Talk)

- **Only for doctoral students.**
- **W** 2 credits
- **4K Lecturers**

Abstract: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

### 900-0156-DRL Summer School I (min 4 days)

- **Only for doctoral students.**
- **W** 2 credits
- **4K Lecturers**

Abstract: Participation in summer or winter schools with a minimum duration of 4 days.

Objective: Participation in summer or winter schools with a minimum duration of 4 days.

### 900-0157-DRL Summer School II (min 4 days)

- **Only for doctoral students.**
- **W** 2 credits
- **4K Lecturers**

Abstract: Participation in summer or winter schools with a minimum duration of 4 days.

Objective: Participation in summer or winter schools with a minimum duration of 4 days.

### 900-0158-DRL Summer School III (min 4 days)

- **Only for doctoral students.**
- **W** 2 credits
- **4K Lecturers**

Abstract: Participation in summer or winter schools with a minimum duration of 4 days.

Objective: Participation in summer or winter schools with a minimum duration of 4 days.

### 900-0159-DRL Summer School I (min 4 days, with Poster or Talk)

- **Only for doctoral students.**
- **W** 3 credits
- **6K Lecturers**

Abstract: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0160-DRL Summer School II (min 4 days, with Poster or Talk) W 3 credits 6K Lecturers

Abstract Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0161-DRL Summer School III (min 4 days, with Poster or Talk) W 3 credits 6K Lecturers

Abstract Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0162-DRL External Conference I (incl. Poster or Talk) W 1 credit 2K Lecturers

Abstract Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0163-DRL External Conference II (incl. Poster or Talk) W 1 credit 2K Lecturers

Abstract Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0164-DRL External Conference III (incl. Poster or Talk) W 1 credit 2K Lecturers

Abstract Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

### Doctorate Humanities, Social and Political Sciences - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>O</td>
<td>Compulsory</td>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Subject Specialisation

### Health Sciences and Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-0302-01L</td>
<td>GCP Basic Course (Modules 1 and 2) Only for Health Sciences and Technology MSc</td>
<td>W</td>
<td>1</td>
<td>1G</td>
<td>G. Senti, C. Fila, R. Grossmann</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>The basic course in &quot;Good Clinical Practice&quot; (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.</td>
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<td>Objective</td>
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<td>Students will get familiar with:</td>
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<td>- Key Ethics documents</td>
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<td>- (Inter)national Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)</td>
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<td>- Sequence of research projects and project-involved parties</td>
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<td>- Planning of research projects (statistics, resources, study design, set-up of the study protocol)</td>
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<td>- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)</td>
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<td>- Roles and responsibilities of project-involved parties</td>
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<td>Students will learn how to:</td>
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<td>- Classify research projects according the risk-based approach of the HRA</td>
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<td>- Write a study protocol</td>
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<td>- Inform participating patients/study subjects</td>
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<td>- Obtain consent by participating patients/study subjects</td>
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<td>- Classify, document and report Adverse Events</td>
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<td>- Handle projects with biological material from humans and/or health-related personal data</td>
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<td></td>
<td>Content</td>
<td></td>
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<td></td>
<td>Module 1: Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator’s Brochure, Patient Information Leaflet, Informed Consent Form)</td>
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<td>Module 2: Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>Current topics in translational medicine presented by speakers from academia and industry.</td>
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<td>Objective</td>
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<td>Getting insight into actual areas and problems of translational medicine.</td>
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<td>Content</td>
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<td>Timely and concise presentations of postgraduate students, post-docs, senior scientists, professors, as well as external guests from both academia and industry will present topics of their interest related to translational medicine.</td>
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<td>Prerequisites / notice</td>
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<td>No compulsory prerequisites, but student should have basic knowledge about biomedical research.</td>
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<tr>
<td>376-0305-00L</td>
<td>ETHEart Joint Scientific Colloquium (Autumn Semester)</td>
<td>W</td>
<td>1</td>
<td>1K</td>
<td>N. Cesarovic, V. Falk, H. Rodriguez Gétina Biefer</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>Lectures, presentations and discussions on chosen topics in biologics, (bio-) materials, devices, sensors, robotics and data science and their relevance for cardiovascular medicine.</td>
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<td>Objective</td>
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<td>Deeper, mutual understanding of current medical challenges and technical solutions in cardiovascular medicine.</td>
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<td></td>
<td>Content</td>
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<td></td>
<td>Timely and didactically structured presentations of postgraduate students, post-docs, senior scientists and professorson topics from Zurich Heart / ETHEart projects, followed by lectures on chosen topics of cardiovascular medicine and research given by leading international clinical scientists in the field.</td>
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<td>Prerequisites / notice</td>
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<td>No compulsory prerequisites, but students should have basic knowledge about cardiovascular system, physiology and biomedical research.</td>
</tr>
<tr>
<td>376-1151-00L</td>
<td>Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>C. Ewald</td>
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<td></td>
<td>Number of participants limited to 30.</td>
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<td>The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention. Learning objectives include:</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td>1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>2. Analyse/compare current molecular/genetic strategies that address these aging problems.</td>
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<td>3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.</td>
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<td>4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.</td>
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<tr>
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<td>Content</td>
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<td>Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.</td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td></td>
<td></td>
<td></td>
<td>No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.</td>
</tr>
<tr>
<td>376-1176-00L</td>
<td>Wearable and Mobile Technologies of the Future - Focus on Sports and Health</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>C. Menon, C. Ahmadianzadeh, M. Elgendy</td>
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<tr>
<td></td>
<td>Number of participants limited to 60.</td>
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<td></td>
<td>Number of participants limited to 60.</td>
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</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 716 of 2416
Abstract  
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

Objective  
Objective 1: 
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: 
Acquire skills to design novel non-invasive technologies for sport and health.

Content  
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electrophysiology, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related technologies. The module part will be presented by representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

376-1791-00L Introductory Course in Neuroscience (University of Zurich)  
W 2 credits 2V  
University lecturers

376-1794-00L Colloquium in Biomechanics  
W 2 credits 2K  

Prerequisites / notice  
For doctoral students of the Neuroscience Center Zurich (ZNZ).

Abstract  
The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.

Objective  
The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.

Content  
1) Human Neuroanatomy I&II  
2) Comparative Neuroanatomy  
3) Building a central nervous system I&II  
4) Synapses I&II  
5) Glia and more  
6) Excitability  
7) Circuits underlying Emotion  
8) Visual System  
9) Auditory & Vestibular System  
10) Somatosensory and Motor Systems  
11) Learning in artificial and biological neural networks

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Abstract  
Current topics in biomechanics presented by speakers from academia and industry.

Objective  
Getting insight into actual areas and problems of biomechanics.

701-0015-00L Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement  
W 2 credits 2S  
B. Vienni Baptista, C. E. Pohl, M. Stauffacher

Abstract  
This seminar is designed for PhD students and PostDoc researchers involved in inter- or transdisciplinary research. It addresses and discusses challenges of this kind of research using scientific literature presenting case studies, concepts, theories, methods and by testing practical tools. It concludes with a 10-step approach to make participants research projects more societally relevant.

Objective  
Participants know specific challenges of inter- and transdisciplinary research and can address them by applying practical tools. They can tackle questions like: how to integrate knowledge from different disciplines, how to engage with societal actors, how to secure broader impact of research? They learn to critically reflect their own research project in its societal context and on their role as scientists.

Content  
The seminar covers the following topics:  
(1) Theories and concepts of inter- and transdisciplinary research  
(2) The specific challenges of inter- and transdisciplinary research  
(3) Collaborating between different disciplines  
(4) Engaging with stakeholders  
(5) 10 steps to make participants research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.
Literature

Literature will be made available to the participants.

The following open access article builds a core element of the course:


available at (open access): http://www.ingentaconnect.com/contentone/oekom/gaia/2017/00000026/00000001/art00011

Prerequisites / notice

Participation in the course requires participants to be working on their own research project.

Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

Fostered competencies

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Food Science

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<td>W</td>
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<td>2K</td>
<td>S. J. Sturla</td>
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Abstract

Participation in weekly seminars on a variety of topics including Food Microbiology, Food Toxicology, Food Biochemistry, Food Processing, Consumer Behavior, Food Technology, and Food Materials and Technology, and oral presentation of a selected published study in one of these areas inspired by participation in the seminars.

Objective

The objectives are to become familiar with and stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the semester presentations.

Transferable Skills

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<td>W</td>
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Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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Abstract

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Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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Objective

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
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Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) W 2 credits 4P Lecturers

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

376-1651-00L Ethics of Life Sciences and Biotechnology W 3 credits 2V A. Blasimme, E. Vayena

Number of participants limited to 100

Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Integration into Scientific Community

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| Abstract | Participation in summer or winter schools with a maximum duration of 3 days. |
| Objective| |

<p>| 900-0152-DRL | Summer School III (1-3 days) Only for doctoral students. | W    | 1 credit | 2K    | Lecturers |
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**Abstract**
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

**Objective**
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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**Doctorate Health Sciences and Technology - Key for Type**

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<td>W</td>
<td>Eligible for credits</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Z</td>
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**Key for Hours**

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**ECTS**
European Credit Transfer and Accumption System

Special students and auditors need special permission from the lecturers.
The course is practically oriented and features guest speakers from leading venture capital firms and start-ups. The course embraces a presentation of recent publications in theoretical computer science, including results by diploma, masters and doctoral candidates.

### Patenting Digital Innovations

**2 credits**

C. Jurytko, A. Lidberg

Seminar in Theoretical Computer Science

**2 credits**

B. Gärtner, M. Hoffmann, N. He, A. Ilic

An essential aspect of any research project is dissemination of the findings arising from the study. Here we focus on oral communication, which includes: appropriate selection of material, preparation of the visual aids (slides and/or posters), and presentation skills.

**Doctoral Seminar Machine Learning (HS22)**

Only for Computer Science Ph.D. students.

**This doctoral seminar is intended for PhD students affiliated with the Institute for Machine Learning. Other PhD students who work on machine learning projects or related topics need approval by at least one of the organizers to register for the seminar.**

**Abstract**

An essential aspect of any research project is dissemination of the findings arising from the study. Here we focus on oral communication, which includes: appropriate selection of material, preparation of the visual aids (slides and/or posters), and presentation skills.

**Objective**

The seminar participants should learn how to prepare and deliver scientific talks as well as to deal with technical questions. Participants are also expected to actively contribute to discussions during presentations by others, thus learning and practicing critical thinking skills.

**Prerequisites / notice**

This doctoral seminar of the Machine Learning Laboratory of ETH is intended for PhD students who work on a machine learning project, i.e., for the PhD students of the ML lab.

### Technology Investing

2 credits

E. Welzl, B. Gärtner, M. Hoffmann, J. Lengler, A. Steger, D. Steurer, B. Sudakov

Seminar in Theoretical Computer Science

**2 credits**

W

B. Gärtner, M. Hoffmann, N. He, A. Ilic

The founder's perspective. Why should you raise venture capital and how? Learn to evaluate the founder friendliness of terms, company approach, strategic decisions, negotiation and valuation.

Fundraising types. Learn about different types of funding and their implications. This includes an overview of the Swiss ecosystem and a discussion of the different types (grants, equity, loans, SAFE, crowd, ...). We also include a practical session on crypto technology for modern fund-raising using launchpads and tokenized shares.

Tying it all together. The last day is focused on simulating an investment committee meeting where the groups present their deal memos and discuss with the audience.

### Patenting Digital Innovations

**1 credit**

A. Illic, B. Best

Number of participants limited to 50.

In this seminar dedicated to digital innovations, we will bust the most stubborn myths around AI software patents such as "Software/AI isn’t patentable", "AI patents are useless because you can’t figure out if they are infringed", and many others. We will look at how AI and software start-ups can use patents to create a strong IP position in a scalable way.

**Abstract**

In this seminar dedicated to digital innovations, we will bust the most stubborn myths around AI software patents such as “Software/AI isn’t patentable”, “AI patents are useless because you can’t figure out if they are infringed”, and many others. We will look at how AI and software start-ups can use patents to create a strong IP position in a scalable way.

**Objective**

- Understand the basics of patenting in the digital space relevant for a global market
- Evaluate patenting opportunities with a more differentiated view on the topic
- Effectively use patents as a cost-effective part of a technology startup’s business plan
- Conduct patent searches, freedom-to-operate analysis and infringement analyses
- Write their first software/AI-related invention disclosure suitable for patenting
Participants will be expected to produce a number of short texts (e.g., draft of a conference abstract) as homework assignments; they will receive individual feedback on these texts during the course. Wherever feasible, elements of participants’ future conference/journal articles can be developed as assignments within the course, so it is likely to be particularly useful for those who have i) their data and are about to begin the writing process, or ii) an MSc thesis they would like to convert for publication.

**263-5255-10L**

**Foundations of Reinforcement Learning (Only Assignments)**

Does not take place this semester. Only for Ph.D. students!

Will be offered again in FS23!

**Content**

This course deals with topics such as:

- understanding the needs of different target readerships,
- managing the writing process efficiently,
- structuring texts effectively,
- producing logical flow in sentences and paragraphs,
- editing texts before submission, and
- revising texts in response to colleagues’ feedback and reviewers’ comments.

Number of participants limited to 15.

**Only for D-INFK doctoral students.**

**Abstract**

In this doctoral seminar, current research at the Institute for Visual Computing will be presented and discussed. The goal is to learn about current research projects at our institute, to strengthen our expertise in the field, to provide a platform where research challenges can be discussed, and also to practice scientific presentations.

**Objective**

In this doctoral seminar, current research at the Institute for Visual Computing will be presented and discussed. The goal is to learn about current research projects at our institute, to strengthen our expertise in the field, to provide a platform where research challenges can be discussed, and also to practice scientific presentations.

**Content**

Current research at the IVC will be presented and discussed.

**Prerequisites / notice**

This course requires solid knowledge in the area of Computer Graphics and Computer Vision as well as state-of-the-art research.

**263-5812-00L**

**Writing for Publication in Computer Science A (WPCS) Z**

2 credits 1G K. A. Lewis

Number of participants limited to 15.

**Only for D-INFK doctoral students.**

**Abstract**

This short course is designed to help junior researchers in Computer Science develop the skills needed to write their first research articles.

**Objective**

Writing for Publication in Computer Science is a short course (5 x 4-lesson workshops) designed to help doctoral students develop the skills needed to write their first research articles. The course deals with topics such as:

- understanding the needs of different target readerships,
- managing the writing process efficiently,
- structuring texts effectively,
- producing logical flow in sentences and paragraphs,
- editing texts before submission, and
- revising texts in response to colleagues’ feedback and reviewers’ comments.

**Content**

Participants will be expected to produce a number of short texts (e.g., draft of a conference abstract) as homework assignments; they will receive individual feedback on these texts during the course. Wherever feasible, elements of participants’ future conference/journal articles can be developed as assignments within the course, so it is likely to be particularly useful for those who have i) their data and are about to begin the writing process, or ii) an MSc thesis they would like to convert for publication.

**263-5813-00L**

**Writing for Publication in Computer Science B (WPCS) Z**

2 credits 1G D. Camorani, K. A. Lewis

Number of participants limited to 15.

**Only for D-INFK doctoral students.**

**Abstract**

This short course is designed to help junior researchers in Computer Science develop the skills needed to write their first research articles.

**Objective**

Writing for Publication in Computer Science is a short course (5 x 4-lesson workshops) designed to help doctoral students develop the skills needed to write their first research articles. The course deals with topics such as:

- understanding the needs of different target readerships,
- managing the writing process efficiently,
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- producing logical flow in sentences and paragraphs,
- editing texts before submission, and
- revising texts in response to colleagues’ feedback and reviewers’ comments.

**Content**

Participants will be expected to produce a number of short texts (e.g., draft of a conference abstract) as homework assignments; they will receive individual feedback on these texts during the course. Wherever feasible, elements of participants’ future conference/journal articles can be developed as assignments within the course, so it is likely to be particularly useful for those who have i) their data and are about to begin the writing process, or ii) an MSc thesis they would like to convert for publication.

**263-3010-00L**

**Big Data**

W 10 credits 3V+2U+4A G. Fourny

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

“Big Data” refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the “fourth paradigm”.

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

Content

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- Physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- Logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- Data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBLR, YAML, protocol buffers, Avro)
- Data shapes and models (tables, trees, graphs, cubes)
- Type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (? , *, +)
- An overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- The most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- Paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- Resource management (YARN)
- What a data center is made of and why it matters (racks, nodes, ...)
- Underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- Optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- Applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Literature

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departments interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- “Information Systems for Engineers” (SQL, relational databases): this Fall
- “Big Data for Engineers” (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
Fostered competencies

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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Transferable Skills

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<td>851-0178-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students</td>
<td>W</td>
<td>1 credit</td>
<td>2U</td>
<td>G. Achermann, E. Bobst, N. Gruber, E. Vayena</td>
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</table>

Abstract

Doctoral students from D-GESS will have the opportunity to register for a discipline-specific course in spring semester 2023.

Objective

Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content

Part I on Moodle

The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II

The second, face-to-face part (group sessions) of this course provides an interactive learning environment (workshop). Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice

For doctoral students only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II).

Number of participants limited to 40

Particularly suitable for students of D-BIOL, D-CHAB, D-HEST

Abstract

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective

Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

851-0180-00L | Research Ethics | W | 2 credits | 2G | G. Achermann, P. Emch |

Number of participants limited to 40

Particularly suitable for students of D-BIOL, D-CHAB, D-HEST

Abstract

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective

Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning
1. Ethics - the basics
1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
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<td>Decision-making</td>
<td>Problem-solving</td>
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<td>Integrity and Work Ethics</td>
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<td>Problem-solving</td>
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<td>Self-awareness and Self-reflection</td>
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</tbody>
</table>


Number of participants limited to 40.

Open to all Master level / PhD students.

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored.

Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

### Content

#### Personal Competencies

- **Creative Thinking**
- **Critical Thinking**
- **Integrity and Work Ethics**
- **Self-awareness and Self-reflection**

#### Social Competencies

- **Communication**
- **Cooperation and Teamwork**
- **Self-presentation and Social Influence**
- **Negotiation**

#### Method-specific Competencies

- **Analytical Competencies**
- **Decision-making**
- **Media and Digital Technologies**
- **Problem-solving**

#### Subject-specific Competencies

- **Concepts and Theories**
- **Techniques and Technologies**
- **Assessed**

### Transferable Skills Course I (1-3 days)

**W** 1 credit 2S Lecturers

**Objective**

- Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

### Transferable Skills Course II (1-3 days, with Poster or Talk)

**W** 1 credit 2S Lecturers

**Objective**

- Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

### Transferable Skills Course III (1-3 days, with Poster or Talk)

**W** 2 credits 4S Lecturers

**Objective**

- Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
Talk
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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<th>Code</th>
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<tr>
<td>900-0112-DRL</td>
<td>Participation in Commission I (min 1 year)</td>
<td>W</td>
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<td>2P</td>
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<td>Abstract</td>
<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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</table>

Autumn Semester 2022
Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL
Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Abstract
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL
Member of Executive Board (min 1 year) W 2 credits 4P Lecturers

Abstract
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective
Educational Science for Teaching Diploma and TC
Course units in Humanities, Social and Political Sciences
Course units in Management, Technology and Economics

851-0373-00L
Learning to Teach ■ W 2 credits 2U B. Volk, M. Lehner, S. Pedrocchi

Abstract
This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities.

Objective
This course imparts a variety of teaching skills which will help Doctoral Teaching Assistants with their teaching tasks.

• discuss learning science and teaching techniques with peers.
• design the introduction of their course/lecture/exercise class.
• develop learning activities according to learning objectives.
• practice classroom assessment techniques in order to measure student learning.
• engage in peer feedback in order to improve own teaching.

Content
We will meet for the kick-off meeting online on the 3rd of October 2022 from 1-3 pm. You will get detailed information together with the invitation email in the first week of the semester. The online phase, where you work through 6 modules in the Moodle course page will end by the 11th of November 2022. We will meet on the 16 or 17th of November 22 for the Consolidation workshop. You will find more information on the course page in Moodle.

Prerequisites / notice
This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities (exercises, excursions, supervision of practicals, lectures, etc.) or those who will assume teaching tasks in the semester following the programme. No previous teacher training is required.

Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<td>900-0150-DRL</td>
<td>Summer School I (1-3 days)</td>
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<td>2K</td>
<td>Lecturers</td>
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<tr>
<td>900-0151-DRL</td>
<td>Summer School II (1-3 days)</td>
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<td>1 credit</td>
<td>2K</td>
<td>Lecturers</td>
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<tr>
<td>900-0152-DRL</td>
<td>Summer School III (1-3 days)</td>
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<tr>
<td>900-0153-DRL</td>
<td>Summer School I (1-3 days, with Poster or Talk)</td>
<td>W</td>
<td>2 credits</td>
<td>4K</td>
<td>Lecturers</td>
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</tbody>
</table>

Abstract
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

Abstract
Participation in summer or winter schools with a maximum duration of 3 days.
Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0154-DRL Summer School II (1-3 days, with Poster or Talk) W 2 credits 4K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0155-DRL Summer School III (1-3 days, with Poster or Talk) W 2 credits 4K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0156-DRL Summer School I (min 4 days) W 2 credits 4K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days.

Objective
Participation in summer or winter schools with a minimum duration of 4 days.

900-0157-DRL Summer School II (min 4 days) W 2 credits 4K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days.

Objective
Participation in summer or winter schools with a minimum duration of 4 days.

900-0158-DRL Summer School III (min 4 days) W 2 credits 4K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days.

Objective
Participation in summer or winter schools with a minimum duration of 4 days.

900-0159-DRL Summer School I (min 4 days, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0160-DRL Summer School II (min 4 days, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0161-DRL Summer School III (min 4 days, with Poster or Talk) W 3 credits 6K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0162-DRL External Conference I (incl. Poster or Talk) W 1 credit 2K Lecturers
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer
and prove your participation with the appropriate certificate.

### Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

### Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

#### 900-0163-DRL
**External Conference II (incl. Poster or Talk)**

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

#### 900-0164-DRL
**External Conference III (incl. Poster or Talk)**

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

### Doctorate Computer Science - Key for Type

| W+ | Eligible for credits and recommended |
| W  | Eligible for credits |
| E- | Recommended, not eligible for credits |
| Z  | Courses outside the curriculum |
| Dr | Suitable for doctorate |
| O  | Compulsory |

### Key for Hours

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<thead>
<tr>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>practical/laboratory course</td>
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<td>independent project</td>
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<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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### ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Doctorate Information Technology and Electrical Engineering


- Subject Specialisation

A minimum of 12 ECTS credit points must be obtained during doctoral studies.

The courses on offer below are only a small selection out of a much larger available number of courses. Please discuss your course selection with your PhD supervisor.

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>151-0371-00L</td>
<td>Advanced Model Predictive Control</td>
<td>W</td>
<td>4</td>
<td>2+1U</td>
<td>M. Zeilinger, A. Carron, L. Hewing, A. Tsiamis</td>
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**Abstract**

Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

**Objective**

Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

**Content**

- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

**Lecture notes / notice**

Lecture notes will be provided.

**Prerequisites / notice**

Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended. Background in linear algebra and stochastic systems recommended.

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<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
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**Abstract**

Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

**Objective**

Students master the basic mathematical concepts and algorithms of estimation and machine learning.

**Content**

- Review of probability theory;
- basics of statistical estimation;
- least squares and linear learning;
- Hilbert spaces;
- singular-value decomposition;
- kernel methods, neural networks, and more

**Lecture notes / notice**

Lecture notes will be handed out as the course progresses.

**Prerequisites / notice**

solid basics in linear algebra and probability theory

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<tr>
<td>227-0146-00L</td>
<td>Analog-to-Digital Converters</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>T. Burger</td>
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**Abstract**

This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.

**Objective**

Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. The student will learn to understand the basic principles behind data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or arithmetic conversion are explained with their principle of operation accompanied with the appropriate mathematical calculations, including the effects of non-idealities in some cases. After successful completion of the course the student should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.

**Content**

- Ideal ADC; limitations of flash converters; the folding principle, residue extraction; folding algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.
- Dual-slope & successive approximation register (SAR) converters: dual slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.
- Algorithmic & pipelined A/D converters: arithmetic conversion principle; sample & hold stage; pipe-lined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.
- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.
- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkle correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding and interpolation.
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.
- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-oder delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.

**Lecture notes / notice**

Slides are available online under https://lis-students.ee.ethz.ch/lectures/analog-to-digital-converters/

**Literature**

- M. Gustavsson et. al., CMOS Data Converters for Communications, Springer, 2010

**Prerequisites / notice**

It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

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<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>J. Lygeros, A. Tsiamis</td>
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**Abstract**

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

**Objective**

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.
### Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

### Lecture notes / notice
Available on the course Moodle platform.

### Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

### Fostered competencies
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<th>Subject-specific Competencies</th>
<th>Methodspecific Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Creative Thinking</td>
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<td>Analytical Competencies</td>
<td>Critical Thinking</td>
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<td>Theory</td>
<td>Problem-solving</td>
<td>Integrity and Work Ethics</td>
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### Literature
- **Physics of Failure and Reliability of Electronic Devices and Systems**
  - **Abstract**: Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.
  - **Objective**: Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.
  - **Content**: Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).
  - **Lecture notes**: Comprehensive copy of transparencies

### 227-0377-00L
- **Abstract**: To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.
- **Objective**: To provide an overview on the research activities of the IEF institute.
- **Content**: Closed-loop identification strategies. Trade-off between controller performance and information available for identification. Additional papers will be available via the course Moodle.
- **Prerequisites / notice**: Control systems (227-0216-00L) or equivalent.

### 227-0417-00L
- **Abstract**: This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.
- **Objective**: To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.
- **Content**: The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity
- **Literature**: T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

### 227-0689-00L
- **Abstract**: Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.
- **Objective**: To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.
- **Content**: Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

### 227-0955-00L
- **Abstract**: Selected topics of the current research activities at the IEF and closely related institutions are discussed.
- **Objective**: Have an overview on the research activities of the IEF institute.

### 227-0974-00L
- **Abstract**: This colloquium for MSc/PhD students at D-ITET discusses research in Translational Neuromodeling (development of mathematical models for diagnostics of brain diseases) and application to Computational Psychiatry/Psychosomatics. The range of topics is broad, incl. computational (generative) modeling, experimental paradigms (fMRI, EEG, behaviour), and clinical questions.
- **Objective**: See above

### 252-0535-00L
- **Abstract**: Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.
- **Objective**: Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

### Fundamentals:
- What is data?
- Bayesian Learning
- Computational learning theory

### Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

### Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

### Lecture notes
No lecture notes, but slides will be made available on the course webpage.

### Literature

### Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### 252-0417-00L Randomized Algorithms and Probabilistic Methods
- **Credits:** 10 credits
- **Time:** 3V+2U+4A
- **Instructor:** A. Steger

**Abstract**
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

**Objective**
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Lecture notes**
Yes.

**Literature**

### 327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation
- **Credits:** 2 credits
- **Time:** 2G
- **Instructor:** M. Trassin

**Abstract**
The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

**Objective**
Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

**Content**
In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectricity from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

**Literature**

### 401-3055-64L Algebraic Methods in Combinatorics
- **Credits:** 6 credits
- **Time:** 2V+1U
- **Instructor:** B. Sudakov

**Abstract**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

### Autumn Semester 2022
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure $A$ one maps its elements to vectors in a linear space, and shows that the set $A$ is mapped to linearly independent vectors. It then follows that the cardinality of $A$ is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Waring theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

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<td>900-0112-DRL</td>
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<tr>
<td>Objective</td>
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</table>
Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Abstract
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) W 2 credits 4P Lecturers

Abstract
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<td>900-0150-DRL</td>
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<td>Abstract</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days.</td>
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</table>

| 900-0157-DRL Summer School II      | 2       | 4K        |
| (min 4 days) Only for doctoral students. |         |           |
| Objective                          |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. | | |
| Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. | | |
| Abstract                           |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. | | |

| 900-0158-DRL Summer School III     | 2       | 4K        |
| (min 4 days) Only for doctoral students. |         |           |
| Objective                          |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. | | |
| Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. | | |
| Abstract                           |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. | | |

| 900-0159-DRL Summer School I       | 3       | 6K        |
| (min 4 days, with Poster or Talk) |         |           |
| Only for doctoral students.       |         |           |
| Objective                          |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. | | |
| Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. | | |
| Abstract                           |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. | | |

| 900-0160-DRL Summer School II      | 3       | 6K        |
| (min 4 days, with Poster or Talk) |         |           |
| Only for doctoral students.       |         |           |
| Objective                          |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. | | |
| Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. | | |
| Abstract                           |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. | | |

| 900-0161-DRL Summer School III     | 3       | 6K        |
| (min 4 days, with Poster or Talk) |         |           |
| Only for doctoral students.       |         |           |
| Objective                          |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion. | | |
| Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. | | |
| Abstract                           |         |           |
| Participation in summer or winter schools with a minimum duration of 4 days. | | |

| 900-0162-DRL External Conference I | 1       | 2K        |
| (incl. Poster or Talk)             |         |           |
| Only for doctoral students.        |         |           |
| Objective                          |         |           |
| Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. | | |
| Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. | | |
| Abstract                           |         |           |
| Participation in conferences outside ETH to foster scientific exchange. | | |

| 900-0163-DRL External Conference II| 1       | 2K        |
| (incl. Poster or Talk)             |         |           |
| Only for doctoral students.        |         |           |
| Objective                          |         |           |
| Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. | | |
| Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. | | |
| Abstract                           |         |           |
| Participation in conferences outside ETH to foster scientific exchange. | | |

| 900-0164-DRL External Conference III| 1       | 2K        |
| (incl. Poster or Talk)              |         |           |
| Only for doctoral students.         |         |           |
| Objective                          |         |           |
| Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. | | |
| Please select your doctoral thesis supervisor as a lecturer | | |
| Abstract                           |         |           |
| Participation in conferences outside ETH to foster scientific exchange. | | |

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 739 of 2416
and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Doctorate Information Technology and Electrical Engineering - Key for Type

<table>
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<tr>
<th>Key for Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<td>O</td>
<td>Compulsory</td>
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Key for Hours

<table>
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<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>364-1013-05L</td>
<td>Organizational Behavior</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>F. Magni</td>
</tr>
<tr>
<td>Abstract</td>
<td>Organizational behavior concerns the study of individual and group-level processes in organizations like creativity, motivation, and leadership. In this PhD course, an overview of major concepts and research insights in organizational behavior is provided. The participants are encouraged to discuss their own work situation as PhD students in relation to the OB insights covered in the course.</td>
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<tr>
<td>Objective</td>
<td>The objectives of the course are:</td>
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<td></td>
<td>• to provide an overview of OB research</td>
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<td>• to discuss major research streams in OB</td>
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<td>• to enable students to reflect their own work situation based on concepts used in OB.</td>
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<tr>
<td>364-1013-06L</td>
<td>Marketing Theory</td>
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<td>1G</td>
<td>F. von Wangenheim</td>
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<tr>
<td>Abstract</td>
<td>The course is taught Florian Wangenheim (ETHZ)</td>
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<tr>
<td>Objective</td>
<td>The purpose of the course is to confront students with current theoretical thinking in marketing, and currently used theories for understanding and explaining buyer and customer behavior in response to marketing action.</td>
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<tr>
<td>Content</td>
<td>In the first class, current understanding of the marketing literature and marketing thought is discussed.</td>
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<tr>
<td></td>
<td>In the following classes, various theories are discussed, particularly in light of their importance for marketing. Economic, psychological and sociological theory will be related to current marketing thought.</td>
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<tr>
<td>364-1110-00L</td>
<td>Foundations of Innovation Studies</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Brusoni</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course will introduce some of the major theoretical threads and controversies in the broad field of innovation. During the first part of the course, the emphasis will be on the evolution of innovation studies. The final part of the course will focus on one of the directions in which those studies have evolved: the field of managerial cognition.</td>
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<tr>
<td>Objective</td>
<td>Students will learn about various perspectives, examine different methodologies, explore some original empirical research, make connections between theory and empirical research, and practice reviewing and identifying insight in research.</td>
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<tr>
<td></td>
<td>1) Be able to display some knowledge on a few major theoretical streams in the area.</td>
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<td>2) Be familiar with the methods, issues and current gaps in the area.</td>
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<td>3) Have practiced skills in finding insight and reviewing the literature.</td>
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<td>4) Have practiced skills in defining research problems and proposing empirical research in this area.</td>
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<tr>
<td>364-0553-00L</td>
<td>Innovation in Digital Space</td>
<td>W</td>
<td>1</td>
<td>1G</td>
<td>G. von Krogh</td>
</tr>
<tr>
<td>Abstract</td>
<td>The purpose of this course is to review and discuss issues in current theory and research relevant to innovation in the digital space.</td>
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<tr>
<td>Objective</td>
<td>Through in-depth analysis of published work, doctoral candidates will identify and appraise theoretical and empirical studies, formulate research questions, and improve the positioning of their own research within the academic debate.</td>
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<tr>
<td>Content</td>
<td>The Internet has a twofold impact on the way individuals and firms innovate. First, firms increasingly draw on digital technology to access and capture innovation-relevant knowledge in their environment. Second, individuals, firms, and other organizations extensively utilize the Internet to create, diffuse, and commercialize new digital products and services. During the past decade, theory and research on innovation in the digital space has flourished and generated extensive insights of relevance to both academia and management practice. This has brought us better understanding of working models, and some fundamental reasons for innovation success or failure. A host of new models and research designs have been created to explore the innovation in the digital space, but these have also brought out many open research questions. We will review some of the existing streams of work, and in the process explore a new research agenda.</td>
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<tr>
<td>Format</td>
<td>The course is organized in one block of 2 days. The course is a combination of pre-readings, presentations by faculty and students, and discussions. The students prepare presentations of papers in order to facilitate analysis and discussion.</td>
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</tbody>
</table>
Hacking for Social Sciences is a guide to programming with data. It is tailored to the needs of a field in which scholars' typical curricula do not contain a strong programming component. Yet this course argues that what the open source community calls a 'software carpentry' - a set of skills and knowledge - becomes increasingly essential as social scientists acquire a network perspective on society. The book teaches applied programming with data and aims to leverage the open source software ecosystem to deal with this new wealth and complexity of data.

Hacking for Social Sciences teaches how to use git version control to collaborate professionally, make your research reproducible and your code base persistent.

- Understand the role of focal components in a data science tech toolbox.
- Learn how to manage and version control source code.
- Hacking for Social Sciences teaches how to use git version control to collaborate professionally, make your research reproducible and your code base persistent.
- Applied data sourcing and data transformation
- Learn how to communicate with SQL databases. Learn how to consume data from different sources using machine to machine communication interfaces (APIs) such as the OpenStreetMap geocoding API / Routing Engine or the KOF data API for macroeconomic time series.

Non-Goals:

Hacking for Social Sciences is not a Statistics, Econometrics or Machine Learning course. Though experience in these fields will help inasmuch that students will have an easier time to motivate investing in programming and to come up with their own application examples, profound methodological knowledge is not a prerequisite.

Content

Hacking for Social Scientists is a guide to programming with data. It is tailored to the needs of a field in which scholars' typical curricula do not contain a strong programming component. Yet this course argues that what the open source community calls a 'software carpentry' level of expertise and fosters interdisciplinary collaboration, as source code continues to become an important communication channel.

The course contains three blocks that are mostly based on the three learning objectives presented above. Hacking for Social Sciences explicitly plans to spread its three blocks over 1-2 months to give students the ability to work on applied examples in between sessions in order to get most out of the subsequent session.

The first block demonstrates the components of a modern data science tech stack, classifies technologies and gives a big picture overview: from languages such as R and Python to container technology such as docker. The second block focuses on git version control, the de facto industry standard to manage source code. Version control is not only crucial to knowledge management and reproducible research, but it is also the backbone of collaboration in distributed teams. The third and final block focuses on data itself and teaches how to obtain data through machine to machine communication. Furthermore, the third block discusses data management in a research project.

Lecture notes

A free and open online book (made with bookdown) is available from https://h4sci.github.io/h4sci-book/. The book/script will be continuously updated during the course to account for questions and participants’ questions. All course materials including, slides, resources and source code will be made available through: https://h4sci.github.io/
The course provides students with the basic skills to understand and assess empirically the technological activities of firms and the literature will be presented in the course. For an introduction into the economics of innovation see G.M. Peter Swann, The Economics of Innovation - an Introduction, Edward Elgar, 2009.


Recent developments in the fields of contract theory, finance, banking, money and macroeconomics.

Understanding recent developments in the fields of contract theory, finance, banking and macroeconomics.

The course focuses on important factors that drive the innovation performance of firms, like innovation capabilities, the use of digital technologies, environmental and innovation policy and it shows how innovation activities relate to firm performance and to the technological dynamics of industries. We also discuss the implications of the findings for effective economic policy-making.

Personal and social skills are also addressed during the course. In particular, there is the possibility to improve communication and presentation skills, the ability to develop arguments for the positions of political representatives, policy-makers, pressure groups, or NGOs in connection with innovation policy-making.

The course consists of two parts. Part I provides an introduction into important topics in the field of the economics of innovation. Part II consists of empirical exercises based on various firm-level data sets, e.g., the KOF Innovation data, data about the digitization of firms, or patent data. In part I, we will learn about ... a) market conditions that encourage firms to invest in R&D (Research and Development) and develop new products and processes. ... b) the role of competition and market structure for the R&D activities of companies. ... c) how digital and environmentally friendly technologies diffuse among firms. ... d) how the R&D activities of firms are affected by economic crises and how firms finance their R&D activities. ... e) how we can measure the returns to R&D activities. ... f) how environmental policies and innovation policies affect the technological activities of a firm. In part II we will use the KOF Innovation Survey data, patent data, data on digitization of firms, or other longitudinal data sources, to investigate empirically the technological activities of firms in relation to the topics introduced in part I.

The course will be provided in the course and in the e-learning environment: https://moodle-app2.let.ethz.ch/course/view.php?id=15120


The course is directed to advanced Master-Students and PhD Students with an interest in empirical studies.
In this course, we will address three blocks of selected problems: (i) estimation of fixed and random effects panel data models for single equations and systems of equations; (ii) estimation of models with endogenous treatment effects or sample selection; (iii) estimation of models with interdependent data (so-called spatial models).

The main agenda of this course is to familiarize students with the estimation of econometric problems with three alternative types of problems: (i) estimation of fixed and random effects panel data models for single equations and systems of equations; (ii) estimation of models with endogenous treatment effects or sample selection; (iii) estimation of models with interdependent data (so-called spatial models). Students will be able to program estimation routines for such problems in STATA and apply them to data-sets. They will be given a data-set and will have to work out empirical problems in the context of a term paper.


For spatial econometrics: I will mostly use papers.

I will prepare a script (based on slides), covering all topics.

**Prerequisite:** Students are expected to attend the doctoral course "Macroeconomic Dynamics" before registering for this workshop.

**Literature**


- For spatial econometrics: I will mostly use papers.

I will prepare a script (based on slides), covering all topics.
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: 03SMDOEC1028

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract

In this seminar series, which is held jointly with Prof. Dr. Woitek and Prof. Dr. Hoffman from the University of Zurich, distinguished international researchers present their current research related to international economic policy. The participating doctoral students are expected to attend the presentations (bi-weekly). Moreover, a critical review has to be prepared for 1 of the papers presented.

Objective

On the one hand, participating students are exposed to research at the frontier of international economic policy research. On the other hand, skills such as critical thinking and preparing reviews are learned.

364-0513-00L Empirical Methods in Energy and Environmental Economics

W 3 credits 2V M. Filippini, to be announced

Abstract

This course is designed for PhD & advanced Masters students who are interested in energy and environmental economics. The focus of the lectures/seminars is on methods of applied econometrics in these fields. The course is composed of lectures on specific topics and a seminar. In the seminar, students will have an opportunity to present own papers or to present and discuss empirical studies.

Objective

The objectives of this course are twofold: first, students will learn about the application of econometric techniques in the fields of energy and environmental economics. Second, through the presentation of their papers or the presentation and discussion of the existing literature, students will also get a sense of how critical thinking can be used to assess empirical research in energy and environmental economics.

Content

Day 1: Thursday, January 9
09:00 – 10:30 Session 1: Multinomial choice, heterogeneity (instructor: Greene)
11:00 – 12:30 Session 2: Multinomial choice, heterogeneity (instructor: Greene)
13:30 – 15:00 Session 3: Latent class and Mixed logit (instructor: Greene)
15:30 – 16:30 Session 3: Latent class and Mixed logit (instructor: Greene)

Day 2: Friday, January 10
08:30 – 10:00 Session 1: Measurement of the energy efficiency (instructor: Filippini)
10:30 – 12:00 Session 2: Structural models (instructor: Houde)
13:00 – 14:30 Session 3: Student Presentations
15:00 – 16:30 Session 3: Student Presentations

Day 3: Saturday, January 11
08:30 – 09:30 Session 1: Seminar by Prof. Kenneth Gillingham (Yale University)
09:30 – 10:30 Session 1: Seminar by Prof. Beat Hintermann (Basel University)
10:30 – 11:30 Session 1: Seminar by Prof. Matt Kotchen (Yale University)
10:30 – 12:30 Session 2: Student Presentations
13:30 – 15:30 Session 3: Student Presentations

Lecture notes

Lecture notes will be made available to the students.

Prerequisites / notice

Students are expected to have attended courses in advanced microeconomics and in econometrics.

363-1136-00L Dynamic Macroeconomics, Innovation and Growth

W 3 credits 2V S. Zelzner

Abstract

Introducing dynamic models and workhorses in macroeconomics, understanding the role of innovation and institutions for economic development and discussing policies to foster innovation and economic growth, with a perspective on how digitization and artificial intelligence will affect our economies.

Objective

After the course, students will be familiar with dynamic general equilibrium theory and the basic workhorses in macroeconomics. Participants will be able to speak the Arrow-Debreu and recursive language and apply the frameworks to interesting issues, such as innovation and growth. Moreover, students will understand how the world has developed over the last centuries and the proximate and fundamental causes of innovation and economic growth. Students will understand and apply the basic models of economic growth and will be able to identify policies to foster innovation and growth and to reduce the large wealth differences in the world. Finally, they understand how digitization and artificial intelligence will drive the economies.

Content

1. Introduction

2. The Arrow-Debreu Approach and Sequential Markets

3. The Neoclassical Growth Model and the Representative Agent Model (with Mathematical Background)

4. Technological Progress and how the World has developed

5. Innovations and Growth (New Growth Theory)

6. Growth Policies and Fundamental Causes for Growth

7. Digitization and Artificial Intelligence
After the course, participants will have a solid understanding of the current state of research on inequality in different fields in economics. Possible topics include distributional national accounts, heterogeneous returns, inheritances, intergenerational mobility, gender inequality in the labor market (topics will also be decided upon depending on the students' interests). Students will present a paper and critically comment on it (as if they would referee the paper). Students will therefore also acquire competences for conferences and participation in the scientific discourse.

The course will start with an introduction into the topic and an overview of inequality research in economics. Inequality has become a buzzword in many paper titles and abstracts, but different areas of economics have sometimes very different approaches to this popular topic. The main part of the course will consist of reading and presenting papers that belong to different areas of economics, including Macroeconomics, Public Economics, and Microeconomics / Labour Economics.

By critically examining the literature, students will also learn what makes a well-written paper. By presenting papers, students will further train their presentation skills and we will take time to give feedback in class on the presentations, too. Oral and written presentation of research are both integral parts of a successful academic career. In the written assignment, finally, students will learn how to write a referee report.

The course will start with an introduction into the topic and an overview of inequality research in economics. Inequality has become a buzzword in many paper titles and abstracts, but different areas of economics have sometimes very different approaches to this popular topic. The main part of the course will consist of reading and presenting papers that belong to different areas of economics, including Macroeconomics, Public Economics, and Microeconomics / Labour Economics.

Below you find the suggestive syllabus for this course. I will provide a list of papers in each of the six blocks at the beginning of the semester, and students will choose a paper to present during the semester (suggestions to present a paper that is not on the list are welcome). Students are required to read all papers discussed in the course. At the end of the semester, they will write a referee report with possible suggestions for future research. The written assignment is due in early January.

### Syllabus
- Aggregate trends in income and wealth inequality
  - Top income and wealth shares
  - Distributional national accounts DINA
  - Wealth income ratios
- Measurement of top wealth and its difficulties
  - Capitalization and heterogeneous returns
  - Tax data and tax evasion
  - Alternative data and its limitations
- Inheritances
  - Their role for wealth inequality
  - Optimal taxation of inheritances
- Intergenerational mobility
  - Measurement
  - Exogenous variation and causal identification
- Gender Inequality in the labour market
  - Gender wage gap
  - Child penalties
- Pandemics and their effects on inequalities
  - Covid-19
  - 1918 Influenza Pandemic ("Spanish Flu")
  - The plague

### Prerequisites / notice
Students who have successfully completed the course "Dynamic Macroeconomics" (364-0559-00L) or "Economics of Innovation and Growth" (363-0562-01L) can not register for this course.

### Literature
14. Current Literature on Digitization and Artificial Intelligence

### Objective
After the course, participants will have a solid understanding of the current state of research on inequality in different fields in economics and, starting from there, will be able to develop their own research ideas. They will further learn how to critically assess and referee a paper, as it is common practice during the referee process, and they will practice their presentation skills and give feedback to each other. The students will therefore also acquire competences for conferences and participation in the scientific discourse.

The target group of this course are PhD students who are interested in writing a paper related to economic inequality. Advanced Master students who are interested in taking the course, especially those who plan to pursue a PhD in Economics afterwards, are welcome, too.

The topic is intentionally kept broad to leave room for individual research interests and cover different areas. This will allow students to get to know the current state of research in different, but related areas and help them develop their own research question.

By critically examining the literature, students will also learn what makes a well-written paper. By presenting papers, students will further train their presentation skills and we will take time to give feedback in class on the presentations, too. Oral and written presentation of research are both integral parts of a successful academic career. In the written assignment, finally, students will learn how to write a referee report.

### Content
- The plague
- 1918 Influenza Pandemic ("Spanish Flu")
Fostered competencies

Subject-specific Competencies: Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies: Analytical Competencies assessed
Social Competencies: Communication assessed
Personal Competencies: Critical Thinking assessed

Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>364-1064-00L</td>
<td>Inaugural Seminar - Doctoral Retreat</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>U. Renold, A. Bommier, P. Egger, R. Finger, G. Grote</td>
</tr>
</tbody>
</table>

Abstract
This course is geared towards first and second-year doctoral candidates of MTEC. It is held as in a workshop style. Students attending this seminar will benefit from interdisciplinary discussions and insights into current and future work in business and economics research.

Objective
The purpose of this course is to
- introduce doctoral candidates to the world of economics, management and systems research at MTEC
- make doctoral candidates aware of silo-thinking in the specific sub-disciplines and encourage them to go beyond those silos
- discuss current issues with regard to substantive, methodological and theoretical domains of research in the respective fields

Transferable Skills

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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</thead>
<tbody>
<tr>
<td>900-0101-DRL</td>
<td>Transferable Skills Course II (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>Lecturers</td>
</tr>
</tbody>
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</thead>
<tbody>
<tr>
<td>900-0102-DRL</td>
<td>Transferable Skills Course III (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2S</td>
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<tbody>
<tr>
<td>900-0103-DRL</td>
<td>Transferable Skills Course I (1-3 days, with Poster or Talk)</td>
<td>W</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
</tr>
</tbody>
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Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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<th>Lecturers</th>
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<tbody>
<tr>
<td>900-0104-DRL</td>
<td>Transferable Skills Course II (1-3 days, with Poster or Talk)</td>
<td>W</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
</tr>
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<tr>
<td>900-0105-DRL</td>
<td>Transferable Skills Course III (1-3 days, with Poster or Talk)</td>
<td>W</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
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Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0106-DRL  Transferable Skills Course I (min 4 days)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days.

900-0107-DRL  Transferable Skills Course II (min 4 days)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days.

900-0108-DRL  Transferable Skills Course III (min 4 days)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days.

900-0109-DRL  Transferable Skills Course I (min 4 days, with Poster or Talk)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0110-DRL  Transferable Skills Course II (min 4 days, with Poster or Talk)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0111-DRL  Transferable Skills Course III (min 4 days, with Poster or Talk)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0112-DRL  Participation in Commission I (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL  Participation in Commission II (min 1 year)
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL  Member of Executive Board (min 1 year)  W  2 credits  4P  Lecturers

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Language Courses ETH/UZH: see Science in Perspective

Educational Science for Teaching Diploma and TC

Integration into Scientific Community

<table>
<thead>
<tr>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>900-0150-DRL</td>
<td>Summer School I (1-3 days)</td>
<td>W</td>
<td>1 credit</td>
<td>2K</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0151-DRL  Summer School II (1-3 days)  W  1 credit  2K  Lecturers

Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0152-DRL  Summer School III (1-3 days)  W  1 credit  2K  Lecturers

Abstract
Participation in summer or winter schools with a maximum duration of 3 days.

Objective
Participation in summer or winter schools with a maximum duration of 3 days.

900-0153-DRL  Summer School I (1-3 days, with Poster or Talk)  W  2 credits  4K  Lecturers

Abstract
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0154-DRL  Summer School II (1-3 days, with Poster or Talk)  W  2 credits  4K  Lecturers

Abstract
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0155-DRL  Summer School III (1-3 days, with Poster or Talk)  W  2 credits  4K  Lecturers

Abstract
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0156-DRL  Summer School I (min 4 days)  W  2 credits  4K  Lecturers

Abstract
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
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<tr>
<th>Code</th>
<th>Course Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>900-0157-DRL</td>
<td>Summer School II (min 4 days) Only for doctoral students.</td>
<td>W</td>
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<td>4K</td>
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<td>Participation in summer or winter schools with a minimum duration of 4 days. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<td>900-0158-DRL</td>
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<td>900-0159-DRL</td>
<td>Summer School I (min 4 days, with Poster or Talk) Only for doctoral students.</td>
<td>W</td>
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<td>Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<td>W</td>
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<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
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### Key for Hours

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<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy exchange on current internal research projects. Training of presentation skills.


ECTS

With manufacturing processes reaching its limits in terms of transistor density on today's computing architectures, efficient utilization of computational resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the "think parallel" mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes

https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/ Class notes, handouts

Literature

• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
• Lecture notes

Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

151-0107-20L High Performance Computing for Science and Engineering (HPCSE) I

Abstract

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

Objective

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

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151-0111-00L Research Seminar in Fluid Dynamics

Abstract

Internal research seminar for graduate students and scientific staffs of the IFD

Objective

Exchange on current internal research projects. Training of presentation skills.

151-0123-00L Experimental Methods for Engineers

Abstract

The course presents an overview of measurement tasks in engineering environments. Different concepts for the acquisition and processing of typical measurement quantities are introduced. Following an initial in-class introduction, laboratory exercises from different application areas (especially in thermofluidics, energy, and process engineering) are attended by students in small groups.

Objective

Introduction to various aspects of measurement techniques, with particular emphasis on thermo-fluidic, energy, and process-engineering applications.

Understanding of various sensing technologies and analysis procedures.

Exposure to typical experiments, diagnostics hardware, data acquisition, and processing.

Study of applications in the laboratory.

Fundamentals of scientific documentation and reporting.

Content

In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy technology, process engineering)

Student participation in 8-10 laboratory experiments (study groups of 3-5 students, dependent on the number of course participants and available experiments)

Lab reports for all attended experiments have to be submitted by the study groups. A final exam evaluates the acquired knowledge individually.

Lecture notes

Presentations, handouts, and instructions are provided for each experiment.

Literature


Prerequisites / notice

Basic understanding in the following areas:

- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

151-0529-00L Computational Mechanics II: Nonlinear FEA

Abstract

The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

Objective

To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be monitored. If for some reason a student cannot attend one of the lectures, the student must select another ETH or University of Zurich seminar related to the field and submit a one page description of the seminar topic.

http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems---controls--151-0563-0.html

http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems---controls--151-0563-0.html

http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems---controls--151-0563-0.html

Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one page summary of the attended lecture. No exceptions to this rule are allowed.

This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.

After completing the course, participants will be able to
• critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world” “developing” “global south” “low and middle-income” and justify their own chosen terminology
• recognize the role of racism and white-supremacy in the development of the Aid industry
• understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
• Debate the merits of international engineering in popular culture and media
• Propose improved SDG indicators that address current shortcomings
• Compare the engineering curricula of different countries to identify relative strengths and shortcomings
• Explain the inherent biases of academic publishing and its impact on engineering failure
• Analyse linkages between the rise of philanthropy and strategic priority areas
• Recommend equitable, just funding models to achieve more sustainable outcomes
• Formulate a vision for the international engineer of the future
Content
Role of international engineering during colonialism
Transition of international engineering following colonialism
White saviourism and racism in international engineering
International engineering in popular culture
The missing role of Engineering Education
Biases academic publishing
The emerging role in Global Philanthropy
The paradox of International funding

Literature

151-9901-00L Scientific Writing for Publication in Engineering
Only for D-MAVT doctoral students.
Number of participants limited to 15 per group.

Abstract
Scientific Writing for Publication in Engineering is a short course (5 half-day workshops) designed to help junior researchers develop the skills needed to write their first research articles in English.

Objective
The course deals with topics such as
• Fitting texts to target readerships and journals
• Managing the writing process efficiently
• Structuring each section of the text effectively
• Producing fluent and reader-focused sentences and paragraphs
• Editing the text before submission
• Revising in response to reviewers’ comments.

Content
Participants produce a number of short texts as homework assignments and receive detailed individual feedback on these during the course.

151-9905-00L Applied Compositional Thinking for Engineers II

Abstract
This course is an introduction to advanced topics in Applied Category Theory focused on the needs of applications. The course favors a computational, constructive, and compositional approach targeted to applications in engineering.

Objective
In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of problems and the design of solutions. Applied Category Theory is a field of mathematics that can help in thinking about precisely such topics. A problem, however, is that this type of mathematics is not traditionally taught -- to date, there exists no easy path for engineers to learn category theory that is approachable and emphasizes engineering applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I).

This course’s goal is not to teach category theory for the sake of it, but to teach the “compositional way of thinking”. Category theory will just be the means towards this end. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.

The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.

Content
Categories
Functors
Co-design problems
Natural transformations
Adjunctions
Traced monoidal categories
Computation:
- From mathematical models to algorithms
- Solving finite co-design problems
- Monads
- Modeling uncertainty

Enriched category theory:
- Profunctors
- Enriched categories
- Negative category theory

Operads

Lecture notes
Slides and notes will be provided.

Literature

Prerequisites / notice
The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Basic algebra (sets, posets, relations, semigroups, groups).

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in the Spring Semester are sufficiently proficient in (1) and (2).

351-0778-00L Discovering Management
Entry level course in management for BSc, MSc and PHD
W 3 credits 3G B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke,
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship. The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and/or appreciate the challenges that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Throughout the course different session preparation assignments, like reading book chapters or case studies, will be handed out to the students on Moodle. This preparation is required to participate in the lectures.

The final exam is requested for all types of students (BSc, MSc, MA, PhD, and Exchange students). It is not possible to retake the exam within the same term or academic year. We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.
Fostered competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
Method-specific Competencies | Analytical Competencies | assessed
| Decision-making | assessed
| Problem-solving | assessed
Social Competencies | Cooperation and Teamwork | not assessed
| Customer Orientation | not assessed
| Leadership and Responsibility | not assessed
Personal Competencies | Adaptability and Flexibility | not assessed
| Creative Thinking | not assessed
| Critical Thinking | not assessed
| Integrity and Work Ethics | not assessed

| 363-0389-00L | Technology and Innovation Management | W | 3 credits | 2G | S. Brusoni, A. Zeijen

**Abstract**
This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

**Objective**
This course intends to enable all students to:
- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

**Content**
This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

**Lecture notes**
Slides will be available on the Moodle page

**Literature**
Readings will be available on the Moodle page

**Prerequisites / notice**
The course content and methods are designed for students with some background in management and/or economics

| 363-0403-00L | Introduction to Marketing | W | 3 credits | 2G | S. Brüggemann

**Abstract**
Students who take this course will increase their knowledge of marketing, its effect on consumer behavior and its role in creating long-term value. The course will introduce important concepts, frameworks and methods for marketing decision-making. A focus will be on managing customer relationships with the help of targeted promotions and data collected through digital technologies.

**Objective**
This course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing. A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

**Content**
The course is designed to be “hands-on”, with opportunities to apply skills on business cases involving real-world marketing data. It will feature guest lectures from industry experts.

The structure of the course will roughly follow the different steps of the value chain, i.e., the set of activities necessary for offering valuable products to customers. First, it will introduce students to psychological theories that help explain behavior, e.g., purchase behavior. It will also familiarize students with different methods from marketing research, which can be used to identify the needs of customers. Next, the course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing.

A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

**Literature**

The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

**Objective**

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

**Content**

The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

**Prerequisites / notice**

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

**Literature**


For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:


Complementary:


GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
"Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.


The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

### 363-0565-00L Principles of Macroeconomics

**Abstract**

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective**

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

**Content**

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

**Lecture notes**

The course webpage (to be found at https://moodle-app2.lethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

**Literature**


This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

**Fostered competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### 363-0711-00L Accounting for Managers

**Abstract**

The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

By attending this course, students will be able to:
- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

**Objective**

This course offers fundamental knowledge for decision making in the context of managers accountable for the financial reporting of different types of business. It helps understand what the financial reports contain and how they are prepared. It introduces the basics of management accounting, which enables managers to make well-informed decisions.

**Content**

The first part of the course is devoted to financial accounting. It teaches the principles of double-entry accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

**Prerequisites / notice**

This is a prerequisite for the course Financial Management.

### 363-0790-00L Technology Entrepreneurship

**Abstract**

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.
### Applied Analysis of Variance and Experimental Design

**Objective**
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real-life examples and cases.

**Content**
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15' Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture rooms.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.


**Literature**

**Prerequisites / notice**
Basic knowledge in international economics and a good background in macroeconomics.

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### Lecture notes

| Lecture notes | Monetary Policy
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>363-1021-00L</td>
<td>W 3 credits</td>
</tr>
<tr>
<td>Abstract</td>
<td>J.-E. Sturm, A. Rathke</td>
</tr>
<tr>
<td>Objective</td>
<td>Monetary Policy</td>
</tr>
<tr>
<td>Content</td>
<td>The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real-world issues.</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Basic knowledge in international economics and a good background in macroeconomics.</td>
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### Subject-specific Competencies

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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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### Method-specific Competencies

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<th>Decision-making</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Project Management</th>
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### Social Competencies

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<th>Communication</th>
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<th>Self-presentation and Social Influence</th>
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### Personal Competencies

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<th>Creative Thinking</th>
<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
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<th>Self-direction and Self-management</th>
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</table>

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### Applied Analysis of Variance and Experimental Design

**Objective**
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**

**Prerequisites / notice**
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

---

### Patents

**Objective**
Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Introduction into intellectual property; prosecution of patent applications; patent information; exploitation and enforcement of patents; peculiarities in pharmaceutics and medicine; social, political and ethical aspects; Trademarks.

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### Lecture slides and material

Lecture slides and case material

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**Data:** 01.11.2022 12:41  **Autumn Semester 2022**  Page 759 of 2416
Basic knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

1. Introduction into industrial property (patents, trademarks, industrial designs);
2. Prosecution of patent applications (patentability);
3. Patent information (patent publications, databases, searches);
4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement);
5. Peculiarities in pharmaceutics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication);
6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions);
7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma-trademarks.

A script is provided in electronic form during the lecture.


None

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
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Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

636-0507-00L Synthetic Biology II

Does not take place this semester.

Students in the MSc Biotechnology (Programme Regulations 2017) may select Synthetic Biology II instead of the Research Project 1.

Abstract
7 months biological design project, during which the students are required to give presentations on advanced topics in synthetic biology (specifically genetic circuit design) and then select their own biological system to design. The system is subsequently modeled, analyzed, and experimentally implemented. Results are presented at an international student competition at the MIT (Cambridge).

Objective
The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.

Content
Presentations on advanced synthetic biology topics (e.g genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence, (DNA synthesis external) implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (www.igem.org).

Lecture notes
Handouts during course

Prerequisites / notice
The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc.

This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April.

Please note that the number of ECTS credits and the actual work load are disconnected.

Transferable Skills

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-2226-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students (MaP Doctoral School)</td>
<td>W</td>
<td>1</td>
<td>2U</td>
<td>L. Schefer, S. Stepanow, M. Trassin</td>
</tr>
</tbody>
</table>

Number of participants limited to 15. Priority is given to doctoral students affiliated with the MaP Doctoral School.

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.
Content
The self-paced e-learning course consists of 5 modules:
(1) Ethics: Introduction to moral theory (with emphasis on practical guidance regarding decision making)
(2) Ethics in Scientific Research: Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).
(3) Collecting Resources: A variety of tools and resources that help identify ethical issues are presented and explained
(4) Setting up a Strategy: Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).
(5) Making Decisions: Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects of Materials, Processes and Manufacturing Technologies. It provides an interactive learning environment. Participants get to apply their knowledge, and they are encouraged to reflect on ethical problems and critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Module</th>
<th>Instructors</th>
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</thead>
<tbody>
<tr>
<td>851-0093-00L</td>
<td>Ethical Issues in the Economy</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>L. Wingert</td>
</tr>
<tr>
<td></td>
<td>Doctoral students can receive credit for the achievements of this course in the section “Transferable Skills”.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>Ecological crises and growing social inequalities rise the urgent question: Is the global way we are doing economics reasonable? – Which kind of wealth is illegitimate? Is a policy of de-growth needed for protecting our ecological niche? Will technological devices e.g. AI-driven market designs for public goods be the solution or is a change of attitudes necessary to cope with such problems?</td>
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<td>Objective</td>
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<td>Participants should learn to know and being enabled to evaluate answers to the following questions:</td>
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<tr>
<td></td>
<td>1. To which extent are economic success and wealth something deserved, and to which extent are they the outcome of lucky circumstances or favorable conditions? And what follows from the answer for the judgment on social inequalities?</td>
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<td>2. How much consumption and growth are enough?</td>
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<td>3. Which commons should not be privatized?</td>
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<td>4. What should entrepreneurs and consumers be responsible for?</td>
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<td>5. Does a sharing economy promote a responsible way of doing business?</td>
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<td>6. Are technologies for regulating production and allocation of resources as well as regulating consumptions of goods apt to cope with problems of social inequality, of protecting our ecological niche, and do they empower producers, investors and consumers to act responsible?</td>
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<td>7. What are the good things and what are the bad things about the global capitalist scheme doing business in the 21st century?</td>
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<td>8. Do we need a de-globalization of doing economics?</td>
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</table>

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<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Module</th>
<th>Instructors</th>
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</thead>
<tbody>
<tr>
<td>851-0180-00L</td>
<td>Research Ethics</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>G. Achermann, P. Emch</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 40</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.</td>
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<td></td>
<td>Objective</td>
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<td></td>
<td>Participants of the course Research Ethics will</td>
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<td></td>
<td>• Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;</td>
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<tr>
<td></td>
<td>• Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;</td>
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</tbody>
</table>
Content

I. Introduction to Moral Reasoning
1. Ethics - the basics
1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!)
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Fostered competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
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<td>Self-awareness and Self-reflection</td>
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</table>

900-0100-DRL Transferable Skills Course I (1-3 days) W 1 credit 2S Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0101-DRL Transferable Skills Course II (1-3 days) W 1 credit 2S Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.
<table>
<thead>
<tr>
<th>Code</th>
<th>Course Description</th>
<th>Credits</th>
<th>Weekly Hours</th>
<th>Lecturers</th>
<th>Details</th>
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<td>Transferable Skills Course III (1-3 days)</td>
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<tr>
<td>900-0103-DRL</td>
<td>Transferable Skills Course I (1-3 days, with Poster or Talk)</td>
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<tr>
<td>900-0104-DRL</td>
<td>Transferable Skills Course II (1-3 days, with Poster or Talk)</td>
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<td>4S</td>
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<td>Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>900-0105-DRL</td>
<td>Transferable Skills Course III (1-3 days, with Poster or Talk)</td>
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<td>4S</td>
<td>Lecturers</td>
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<tr>
<td>900-0106-DRL</td>
<td>Transferable Skills Course I (min 4 days)</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
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<tr>
<td>900-0107-DRL</td>
<td>Transferable Skills Course II (min 4 days)</td>
<td>2</td>
<td>4S</td>
<td>Lecturers</td>
<td>Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>900-0108-DRL</td>
<td>Transferable Skills Course III (min 4 days)</td>
<td>2</td>
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<td>Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>900-0109-DRL</td>
<td>Transferable Skills Course I (min 4 days, with Poster or Talk)</td>
<td>3</td>
<td>6S</td>
<td>Lecturers</td>
<td>Only for doctoral students. Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
</tr>
</tbody>
</table>
Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
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<td>900-0110-DRL</td>
<td>Transferable Skills Course II (min 4 days, with Poster or Talk)</td>
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<td>6S</td>
<td>Lecturers</td>
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<tr>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>Objective</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
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<td>3</td>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<td>Objective</td>
<td>Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>900-0112-DRL</td>
<td>Participation in Commission I (min 1 year)</td>
<td>W</td>
<td>1</td>
<td>2P</td>
<td>Lecturers</td>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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<tr>
<td>Objective</td>
<td>Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.</td>
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<td>900-0113-DRL</td>
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<td>2P</td>
<td>Lecturers</td>
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<tr>
<td>Abstract</td>
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<td>Objective</td>
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<tr>
<td>900-0114-DRL</td>
<td>Member of Executive Board (min 1 year)</td>
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<tr>
<td>Abstract</td>
<td>Active participation in the presidium or executive board of a university group for at least 1 year.</td>
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<td>Objective</td>
<td>Active participation in the presidium or executive board of a university group for at least 1 year.</td>
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Integration into Scientific Community

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>900-0150-DRL</td>
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<td>W</td>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days.</td>
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<tr>
<td>Objective</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days.</td>
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<tr>
<td>900-0151-DRL</td>
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<td>2K</td>
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<td>Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.</td>
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<tr>
<td>Abstract</td>
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<tr>
<td>Objective</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days.</td>
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<tr>
<td>900-0152-DRL</td>
<td>Summer School III (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2K</td>
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<tr>
<td></td>
<td>Please select your doctoral thesis supervisor as a lecturer</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 764 of 2416
and prove your participation with the appropriate certificate.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Lecturers</th>
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<td>Summer School I (1-3 days, with Poster or Talk)</td>
<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>Abstract</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>Objective</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>900-0154-DRL</td>
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<td>4K Lecturers</td>
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<td>Abstract</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
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<td>900-0155-DRL</td>
<td>Summer School III (1-3 days, with Poster or Talk)</td>
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<td>Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
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<td>Objective</td>
<td>Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>900-0156-DRL</td>
<td>Summer School I (min 4 days)</td>
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<td>4K Lecturers</td>
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<tr>
<td>Abstract</td>
<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>Objective</td>
<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>900-0157-DRL</td>
<td>Summer School II (min 4 days)</td>
<td>W 2</td>
<td>4K Lecturers</td>
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<tr>
<td>Abstract</td>
<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>Objective</td>
<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>900-0160-DRL</td>
<td>Summer School II (min 4 days, with Poster or Talk)</td>
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<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>Objective</td>
<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>900-0161-DRL</td>
<td>Summer School III (min 4 days, with Poster or Talk)</td>
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<td>6K Lecturers</td>
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<tr>
<td>Abstract</td>
<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>Objective</td>
<td>Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>900-0162-DRL</td>
<td>External Conference I (incl. Poster or Talk)</td>
<td>W 1</td>
<td>2K Lecturers</td>
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<tr>
<td>Abstract</td>
<td>Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.</td>
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<tr>
<td>Objective</td>
<td>Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.</td>
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</tbody>
</table>
900-0163-DRL  External Conference II (incl. Poster or Talk)  W  1 credit  2K  Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0164-DRL  External Conference III (incl. Poster or Talk)  W  1 credit  2K  Lecturers

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Doctorate Mechanical and Process Engineering - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
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</thead>
<tbody>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Subject Specialisation

#### General Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>327-0710-00L</td>
<td>Polymer Physics</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>H. C. Ottinger, M. Kröger</td>
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<tr>
<td>Abstract</td>
<td>Group seminar in polymer physics</td>
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<tr>
<td>Objective</td>
<td>Continued and deeper education in polymer physics, in particular, for Ph.D. students</td>
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<tr>
<td>Content</td>
<td>Presentation and discussion of ongoing research projects by members of the polymer physics group and external speakers</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Irregular series of presentations (see announcements)</td>
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<tr>
<td>327-0711-00L</td>
<td>Metal Physics and Technology Seminar</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>J. F. Löffler</td>
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<tr>
<td>Abstract</td>
<td>Seminar for Ph.D. students and researchers in the area of metal physics and technology</td>
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<tr>
<td>Objective</td>
<td>Detailed education of researchers in the area of metallic materials</td>
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<tr>
<td>Content</td>
<td>Presentation and discussion of latest research results concerning basic principles of metals research and development of new metallic materials.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Requirements: Involvement in research activities. Lectures are generally in English.</td>
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<td>327-0712-00L</td>
<td>Nanometallurgy</td>
<td>E-</td>
<td>0</td>
<td>2S</td>
<td>R. Spolenak</td>
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<tr>
<td>Abstract</td>
<td>Seminar for Ph.D. students and researchers in the area of nanometallurgy</td>
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<tr>
<td>Objective</td>
<td>Detailed education of researchers in the area of nanometallurgy.</td>
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<tr>
<td>327-1300-00L</td>
<td>Joint Group Seminar</td>
<td>E-</td>
<td>0</td>
<td>1S</td>
<td>M. Fiebig, N. Spaldin</td>
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<tr>
<td>Abstract</td>
<td>Only for D-MATL doctoral students</td>
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<tr>
<td>Objective</td>
<td>Seminar for PhD students and researchers in condensed-matter physics.</td>
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<tr>
<td>Content</td>
<td>Improving the interaction of researchers in the participating groups.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Presentation and discussion of contemporary research. Own scientific contributions.</td>
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<tr>
<td>327-6100-00L</td>
<td>Materials Colloquium</td>
<td>E-</td>
<td>0</td>
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<td>Professors, further speakers</td>
</tr>
<tr>
<td>Abstract</td>
<td>The Materials Colloquium is a platform for PhD students, postdoctoral researchers, group leaders, senior scientists, and professors to present their own and their group’s research to their colleagues. The apero following the colloquium has the purpose to stimulate discussions and to promote networking in a relaxed, more informal environment. The Colloquium is open to all who are interested.</td>
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<tr>
<td>Objective</td>
<td>Learn about recent research in the field of materials science.</td>
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<tr>
<td>Content</td>
<td><a href="https://sam.mat.ethz.ch/mc2022/">https://sam.mat.ethz.ch/mc2022/</a></td>
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<tr>
<td>327-0721-00L</td>
<td>Writing for Publication in Materials Science</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>K. A. Lewis</td>
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<tr>
<td>Abstract</td>
<td>Only for D-MATL doctoral students</td>
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<tr>
<td>Objective</td>
<td>This short course is designed to help junior researchers in Materials Science develop the skills needed to write their first research articles. The course deals with topics such as</td>
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<tr>
<td>Content</td>
<td>- identifying target readerships and selecting outlets,</td>
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<td></td>
<td>- managing the writing process efficiently.</td>
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<td></td>
<td>- structuring the text effectively.</td>
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<td></td>
<td>- producing logical flow in sentences and paragraphs,</td>
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<tr>
<td></td>
<td>- editing the text before submission, and</td>
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<td>- revising the text in response to reviewers' comments.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Participants will be expected to produce a number of short texts as homework assignments and will receive individual feedback on these during the course. Wherever feasible, elements of participants' future research articles can be developed as assignments within the course, so it is likely to be particularly useful for those who have their data and are about to begin the writing process.</td>
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<tr>
<td></td>
<td>Part 1: Introduction to the course; the writing context; identifying target readers and targeting journals; using model texts; activating vocabulary; writing clear English sentences; the English verb system in research publications - using tense, aspect, and voice</td>
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<td>Part 2: The writing process; structural decisions (IMRD and variations); from plan to draft; basics of paragraph structure; reader-friendly paragraph structure; patterns and tools for creating logical flow; the English noun phrase in research publications</td>
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<td>Part 3: The experimental narrative; process descriptions, explanation and justification; data commentaries; embedding figures, diagrams, etc.</td>
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<td>Part 4: Introductions; creating a research space (CARS); writing about the literature; reference, citation, paraphrase and quotation; discussion and conclusion sections; overview of abstracts and titles</td>
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<td>Part 5: Managing the strength of the claim - hedging and emphasis; punctuation and style; the editing process; responding to reviewers’ comments; preparing writing portfolios for assessment and research articles for submission.</td>
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<td>This short course is designed to help junior researchers in Materials Science develop the skills needed to write their first research articles.</td>
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<td>Notice</td>
<td>For PhD students, postdocs and others, a fee will be charged (<a href="https://scopem.ethz.ch/education/MTP0.html">https://scopem.ethz.ch/education/MTP0.html</a>).</td>
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All applicants must additionally register on this form: (link will follow)
The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content
During the course, students learn through lectures, demonstrations, and hands-on sessions how to set up and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- Electron sources, electron lenses and probe formation
- Beam/specimen interaction, image formation, image contrast and imaging modes.
- Sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Type</th>
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<tbody>
<tr>
<td>327-2126-00L</td>
<td>Microscopy Training TEM I - Introduction to TEM</td>
<td>2</td>
<td>P. Zeng, E. J. Barthazy Meier, A. G. Bittermann, F. Gramm, A. Sologubenko</td>
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</tbody>
</table>

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP0.html).

All applicants must additionally register on this form: (link will follow)
The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract
The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

Objective
Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

Content
Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.
The FIRST Introduction Day comprises general and access information, cleanroom basics, infrastructure information, safety training, cleanliness seminar, chemistry seminar and safety test. The introduction day is mandatory for each user who intends to use the FIRST cleanrooms independently of level of experience.

Objective
Access to the FIRST cleanroom.

Content
The FIRST Introduction Day comprises general and access information, cleanroom basics, infrastructure information, safety training, cleanliness seminar, chemistry seminar and safety test. The introduction day is mandatory for each user who intends to use the FIRST cleanrooms independently of level of experience.

Lecture notes
https://moodle-app2.let.ethz.ch/user/index.php?id=12731

Advanced Manufacturing (MaP Doctoral School)

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>064-0025-22L</td>
<td>Introduction to Computational Research in Architecture, Engineering, Fabrication and Construction</td>
<td>W</td>
<td>2</td>
<td>3K</td>
<td>P. Block</td>
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Abstract
Does not take place this semester.

Objective
Understand the scope and relevance of computational methods for architecture and engineering research and practice, i) the theoretical background of fundamental data structures, ii) the basic principles of algorithmic design; iii) the basic principles of algorithmic design; iv) implement basic versions of prevalent algorithms related to architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation; v) use sophisticated algorithms available through open-source libraries to solve real-world problems; and, vi) use common CAD tools as interfaces to self-implemented solutions.

Content
Course consists of a few lectures, several tutorials and project-based exercises. Topics include:
- intro to geometry processing, data structures, topology, numerical computation
- intro Python programming
- intro COMPAS open-source framework (https://compas-ev.github.io)
- domain-specific case studies (e.g. on architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation)

Prerequisites / notice
Priority is given to PhD students.

101-0139-00L Scientific Machine and Deep Learning for Design and Construction in Civil Engineering

Abstract
The PhD-level course (primarily for A&T PhDs) will introduce computational methods for architecture, engineering, fabrication & construction, incentivising computational literacy. Students learn the theoretical background and basic implementation details of fundamental data structures and algorithms, and to solve real-world problems using the COMPAS framework and other open-source libraries.

Objective
Understand the scope and relevance of computational methods for architecture and engineering research and practice, i) the theoretical background of fundamental data structures, ii) the basic principles of algorithmic design; iii) the basic principles of algorithmic design; iv) implement basic versions of prevalent algorithms related to architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation; v) use sophisticated algorithms available through open-source libraries to solve real-world problems; and, vi) use common CAD tools as interfaces to self-implemented solutions.

Content
Course consists of a few lectures, several tutorials and project-based exercises. Topics include:
- intro to geometry processing, data structures, topology, numerical computation
- intro Python programming
- intro COMPAS open-source framework (https://compas-ev.github.io)
- domain-specific case studies (e.g. on architectural geometry, structural design, robotic assembly, volumetric modeling & 3D printing, high-performance computation)

Prerequisites / notice
Priority is given to PhD students.

101-0167-01L Fibre Composite Materials in Structural Engineering

Abstract
1) Lamina and Laminate Theory
2) FRP Manufacturing and Testing Methods
3) Design and Application of Externally Bonded Reinforcement to Concrete, Timber, and metallic Structures
4) FRP Reinforced Concrete, All FRP Structures
5) Measurement Techniques and Structural Health Monitoring

Objective
At the end of the course, you shall be able to
1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessray testing and SHM techniques for FRP structures,
3) Continue your education as a phd student in this field.
Content

Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes

Power Point Presentations available online at www.empa.ch/abt303

Literature


3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019


Prerequisites / notice

1) Laboratory Tours and Demonstrations: Empa Structural Engineering Laboratory including FRP Composites, Shape Memory Alloys, Timber Elements, Large Scale Testing of Structural Components

2) Working with Composite Materials in the Laboratory (application, testing, etc)

102-0357-00L Waste Recycling Technologies W 3 credits 2G R. Bunge

Abstract

Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

Objective

At the core of this course is the separation of solids from bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.

Content

Introduction

Waste Recycling: Scope and objectives

Waste recycling technologies in Switzerland

Fundamentals

Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials

Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles

Flow sheet basics: Balancing mass flows

Standard processes: batch vs. continuous

Assessment of separation success: Separation function; grade vs. recovery

Separation Processes

Separation according to size and shape (Classification); Screening, Flow separation

Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology, Froth flotation

Lecture notes

The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Literature

A list of recommended books will be provided.

Prerequisites / notice

The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

151-0293-00L Combustion and Reactive Processes in Energy and Materials Technology W 4 credits 2V+1U+2A N. Noiray, F. Ernst, C. E. Frouzakis

Abstract

This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles formation. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective

The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content


Lecture notes

No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II W 4 credits 3G A. Kunz

Abstract

This course will provide a deeper knowledge of today’s VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.
### Mechanics of Composite Materials

**W 4 credits 2V+1U  G. Pappas**

**Abstract**  
Focus is on laminated fibre reinforced polymer composites. The courses treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

**Objective**  
To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

**Content**  
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Thin ply composite shells & effects of material non-linearity

**Lecture notes**  
The handout is available in German and English. Script, handouts, exercises and additional material are available in PDF-format on moodle page of the lecture. https://moodle-app2.let.ethz.ch/course/view.php?id=2610

### Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis

**W 4 credits 3G  E. Hosseini**

**Abstract**  
An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

**Objective**  
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.
Content

- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (steels, Ti6Al4V, Inconel, Al alloys),
- Design for additive manufacturing
- Artificial intelligence for AM

Exercise sessions use COMSOL, ANSYS,ABAQUS packages for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. COMSOL, ANSYS and ABAQUS agreed to support the course by providing licenses for the course attendees and therefore the students can install the packages on their own systems.

Lecture notes

Handouts of the presented slides.

Literature

No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

Prerequisites / notice

A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.

Fostered competencies

| Subject-specific Competencies                  | Concepts and Theories | assessed |
| Method-specific Competencies                  | Techniques and Technologies | assessed |
| Method-specific Competencies                  | Analytical Competencies | assessed |
| Method-specific Competencies                  | Decision-making | assessed |
| Method-specific Competencies                  | Problem-solving | assessed |
| Personal Competencies                         | Creative Thinking | assessed |
| Personal Competencies                         | Critical Thinking | assessed |

151-0623-00L ETH Zurich Distinguished Seminar in Robotics, Systems and Controls

Abstract

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be assessed.

Objective

Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.

Content

This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be assessed. If for some reason a student cannot attend one of the lectures, the student must select another ETH or University of Zurich seminar related to the field and submit a one page description of the seminar topic. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a suggestion of other lectures.

Prerequisites / notice

Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one page summary of the attended lecture. No exceptions to this rule are allowed.

151-0703-00L Operational Simulation of Production Lines

Abstract

The students learn the application of the event-driven and computer-based simulation for layout and operational improvement of production facilities by means of practical examples. The simulation provides an essential basis for digital twins in Industry 4.0.

Objective

The students learn the right use of (Who? When? How?) of the event-driven and computer-based simulation in the illustration of the operating procedures and the production facilities. The simulation is an important basis for creating a digital twin in the context of Industry 4.0.

Operating simulation in the productions, logistic and scheduling will be shown by means of practical examples. The students should make their first experiences in the use of computer-based simulation.

Content

- Application and application areas of the event-driven simulation
- Simulation in the context of Industry 4.0 (digital twin)
- Exemplary application of a software tool (Technomatrix-Simulation-Software)
- Internal organisation and functionality of simulation tools
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting
- Application on the facilities projecting
- Application on the facilities projecting
- Application on the facilities projecting
- Application on the facilities projecting

The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example.

Lecture notes

Will be sent by email before the lecture (pdf).

Literature

A bibliography will be given during the lectures.

Prerequisites / notice

Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (MAVT, MTEC).

Fostered competencies

| Subject-specific Competencies                  | Concepts and Theories | assessed |
| Method-specific Competencies                  | Techniques and Technologies | assessed |
| Method-specific Competencies                  | Analytical Competencies | assessed |
| Method-specific Competencies                  | Decision-making | assessed |
| Method-specific Competencies                  | Media and Digital Technologies | assessed |
| Method-specific Competencies                  | Problem-solving | assessed |
| Method-specific Competencies                  | Project Management | assessed |
| Social Competencies                           | Cooperation and Teamwork | assessed |
| Social Competencies                           | Customer Orientation | assessed |
| Personal Competencies                         | Sensitivity to Diversity | assessed |
| Personal Competencies                         | Adaptability and Flexibility | assessed |
| Personal Competencies                         | Creative Thinking | assessed |
| Personal Competencies                         | Critical Thinking | assessed |
| Personal Competencies                         | Integrity and Work Ethics | assessed |
| Personal Competencies                         | Self-awareness and Self-reflection | assessed |
| Personal Competencies                         | Self-direction and Self-management | assessed |

151-0717-00L Mechanical Production: Assembly, Joining and
Coating Technology

Abstract
Understanding of the complexity of the assembly process as well as its meaning as success and cost factor. The assembly with the different aspects of adding, moving, adjusting, controlling parts etc., adding techniques, separable and unsolvable connections. Assembly plants. Coating techniques and their tasks, in particular corrosion protection.

Objective
To understand assembly in its full complexity and its paramount importance regarding cost and financial success. An introduction into a choice of selected joining and coating techniques.

Content
Assembly as combination of several classes of action like, e.g., joining, handling, fine adjustments, etc. Techniques for joining objects temporarily or permanently. Assembly systems. Coating processes and their specific applications, with particular emphasis on corrosion protection.

Lecture notes
No Script

Prerequisites / notice
Recommended to the focus production engineering.

Majority of lecturers from the industry.

151-0719-00L Quality of Machine Tools - Dynamics and Metrology at Micro and Submicro Level

Objective
Knowledge of
- principal design of machine tools
- errors of linear and rotational axes and of machine tools,
- influence of errors on the workpiece (error budgeting),
- dynamics of mechanical systems
- measurement data acquisition / digital signal analysis
- experimental modal analysis
- geometric, kinematic, thermal, dynamic testing of machine tools
- test uncertainty
- machine tool capability

Content
Metrology for production, machine tool metrology
- basics, like principal machine tool design and machine tool coordinate system
- principal design and errors of linear and rotational axes
- error budgeting, influence of machine errors on the workpiece
- geometric and kineatic testing of machine tools
- reversal measurement techniques, multi-dimensional machine tool metrology
- thermal influences on machine tools and testing these influences
- test uncertainty, simulation
- basic concepts of dynamics of mechanical systems and vibration theory
- sensors and excitation systems
- mode fitting, experimental modal analysis
- testing of drives and numerical control
- machine tool capability

Lecture notes
Documents are provided during the course. English handouts available on request.

151-0720-00L Colloquium on Manufacturing Technology

Objective
Continuous further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

Content
Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

Lecture notes
No Script

Prerequisites / notice
- Students must have participated and passed the courses Manufacturing, Production Machines I and Forming Technology III - Forming Processes.
- Further training with specialized lectures and large participation from the industry.

Language: Help for English speaking students on request.

151-0729-00L Welding Technology

Objective
The students will gain the competence and understanding to select welding processes properly, to specify the seam preparation and to predict the achievable welding result.

Content
The course provides a survey over the mostly used welding technologies and a basic metallurgical understanding for planning and realization of welded joints.

Lecture notes
Will be distributed accompanying the course progress together with the lecture slides.

Prerequisites / notice
The course is oriented towards the requirements of IW / SVS and is part of the program to attain the international welding engineer diploma (IWE).

151-0733-00L Basics and Processes of Metal Forming

Objective
Acquaintance with forming processes. Determination of forming processes. Interpretation of forming manufacturing

Content
The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, re extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.

Lecture notes
Ja
Applied Finite Element Analysis

Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

Objective

The goal of the lecture is to provide the students with the fundamentals of the non-linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the non-linear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

Content

- introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

Lecture notes

Lecture slides

Literature


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Engineering Design Optimization

The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them.

Objective

The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.

Content


Lecture notes

available on Moodle

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Design for Additive Manufacturing

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchowj@ethz.ch).

Abstract

This course focuses on the design, fabrication, and testing of components produced by additive manufacturing (AM) technologies. The course includes a project based on a real-world problem in which students design, fabricate and iteratively optimize functional AM parts using an appropriate AM technology.

Objective

In this course fundamental knowledge of Design for Additive Manufacturing (AM). The course will prepare the students to:

- Apply fundamental AM processes (metal and plastics)
- Apply the AM design guidelines
- Adopt AM in an industrial environment
- Apply design tools and methods in AM
- Create an added value of AM
- Work in a project-based product development team

Content

Parallel to the lectures the students design, manufacture and test prototypes in a project in different product development stages.

The course is addressing the following topics:

- State of the art AM Processes for metal and plastics (LPBF, BJ, MJF, SLS, FDM)
- Design guidelines in AM
- Industrial adoption of AM
- Value creation and business models for AM
- Design tools and methods for AM
- Quality management in AM
- Industry cases of AM applications
- Problem solving and creativity
- Agile Development

Lecture notes

Script and handouts are available in PDF-format.
Adaptability and Flexibility

Analytical Competencies
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Prerequisites / notice
This course is for master's students.

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchow@ethz.ch).

The successful completion of the course requires active participation in the project, the lecture and the oral exam.

Final grades are based on the performance in the projects, the oral examination and the performance and the participation in the lecture.

### 363-0445-00L Production and Operations Management

**Abstract**
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

**Objective**
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

**Content**
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM.

Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

**Literature**
Suggested literature is provided in the syllabus.

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Method-specific Competencies**
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### 529-0455-00L Laser for Micro- and Nanostructuring

**Abstract**
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as micro lithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

**Literature**
Christoph Klahn; Mirko Meboldt: Entwicklung und Konstruktion für die Additive Fertigung - Grundlagen und Methoden für den Einsatz in industriellen Endkundenprodukten
Vogel Business Media, Würzburg
ISBN: 978-3-8343-3395-7

Ian Gibson; David Rosen; Brent Stucker: Additive manufacturing technologies - 3D printing, rapid prototyping, and direct digital manufacturing
Springer, New York
ISBN: 978-1-4939-2112-6

Suggested literature is provided in the syllabus.

**Prerequisites / notice**
This course is for master's students.

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchow@ethz.ch).

The successful completion of the course requires active participation in the project, the lecture and the oral exam.

Final grades are based on the performance in the projects, the oral examination and the performance and the participation in the lecture.
Multiphysics Modeling and Simulation

Lecturers

Communication not assessed

Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano structuring. Several applications which are still in the research state, e.g. non-optical lithographies, will be discussed together with industrial applications, such as microlithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Adaptability and Flexibility

This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

Analytical Competencies

2V+2U not assessed

The 'Chemical Product Design' course teaches students quantitative concepts to analyze, select and transform theoretical concepts from chemistry and engineering into valuable real-world products. Basic chemistry and chemical engineering knowledge is required (Diffusion, Thermodynamics, Kinetics, ..).

Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics, ..).

Part A: The 'Chemical Product Design' course starts with discussing questions along, 'What is a chemical product, and why do people pay for it? How does a given compound in a specific setting provide a service?' We then learn how to translate new, often ill-defined wishes or ideas into quantifiable specifications.

Part B: Thermodynamic and kinetic data allow sharp selection criteria for successful products. We learn how to deal with insufficient data and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Part C: Manufacturing of commodity products, devices and molecular products: Chemical reactors, separation and detection or isolation units as part of a toolbox. Planning of manufacturing and decisions based on hard data. Providing quantitative answers on potential value and development of robust case models to evaluate their technical and financial constraints. How can parameters of a running process in one industry be scaled into another industry? Can dimensionless engineering numbers be applied beyond traditional chemical processes?

Students are expected to actively develop chemical products along the course. Contributions will be made individually, or in small groups, where a larger topic is studied.


Prerequisites: Basic chemistry and chemical engineering knowledge (Diffusion, Thermodynamics, Kinetics, ..).

Lecture notes

The script (a copy of the slides) will be handed out during the first lecture.

Literature


FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.


As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics. Moreover, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics. Acoustofluidics is a rapidly developing field that focuses on the study of fluid flow and manipulation using ultrasound. It has applications in medicine, manufacturing, and robotics. Acoustofluidics can be used to manipulate fluids at the microscale, allowing for precise control of fluid flow and mixing. This technology is finding applications in a variety of fields, including microfluidics, microgravity, and biotechnology.

Lecture handouts will be posted online.

### Content
- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

### Lecture notes
Lecture handouts will be posted online.

### Fostered competencies
#### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

#### Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

#### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and homework.
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

The lecture will be taught in English.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0620-00L</td>
<td>Embedded MEMS Lab</td>
<td>5</td>
<td>C. Hierold, M. Haluska</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out: - Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures - Packaging and electrical connection of a MEMS device - Testing and characterization of the MEMS device - Written documentation and evaluation of the entire production, processing and characterization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites</td>
<td>The lecture provides sufficient information for the participants to successfully participate in the course.</td>
<td></td>
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</tbody>
</table>
This course aims to familiarize motivated M/BSc students with some of the basic phenomena of particles at the nanoscale, thereby providing guidance throughout the course. Lectures include some of the following:
- Overview & Project Presentation
- Particle Size Distribution
- Particle Diffusion
- Coagulation
- Agglomeration & Coalescence
- Particle Growth by Condensation
- Control of particle size & structure during gas-phase synthesis
- Multi-scale design of aerosol synthesis of particles
- Particle Characterization
- Aerosol manufacture of nanoparticles
- Forces acting on Single Particles in a Flow Field
- Fixed and Fluidized Beds
- Separations of Solid-Liquid & Solid-Gas systems
- Emulsions/droplet formation/microfluidics
- Gas Sensors
- Coaching for proposal & report writing as well as oral presentations

Literature
Aerosol Processing of Materials, T. Koda M. Hampden-Smith, Wiley, 1999
Prerequisites / notice

FluidMechanik I, Thermodynamik I&II & "clean" 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As exceptional effort will be required! Having seen "Chasing Mavericks" (2012) by Apted & Henson, "Unbroken" (2014) by Angelina Jolie and, in particular, "The Salt of the Earth" (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).

151-0913-00L Introduction to Photonics W 4 credits 2V+2U R. Quidant, J. Ortega Arroyo

Abstract

This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.

Content

I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes

Class notes and handouts

Literature

Optics (Hecht) - Pearson

Prerequisites / notice

Physics I, Physics II

227-0053-00L High-Frequency Design Techniques W 4 credits 2V+2U C. Bolognesi, T. Popovic

Abstract

Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective

Introduce to wireless, radio spectrum, review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, antenna basics.

Content

Familiarize students with the essential tools and principles exploited in high-frequency design. Introduction to circuit simulation.
4G
This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.

Objective
You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions.
You know how waves interact with matter and about nonlinear and resonant effects.
You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.

Content
The course covers the following topics:
- Generic time-harmonic electromagnetic fields
- Fundamental solutions of the wave equation
- Wave propagation in various types of materials
- Interaction of waves with matter
- Nonlinear effects
- Resonant effects
- Applications like scattering, waveguiding, radiation
- Radio frequency and optical antennas

Lecture notes
Lecture notes and slides will be handed out during the lectures.

Prerequisites / notice
Remark: the lecture succeeds «Advanced Electromagnetic Waves» and reorients itself to materials, effects, and applications with waves.

227-0157-00L
Semiconductor Devices: Physical Bases and Simulation

Abstract
The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

Objective
The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

Content
The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

Lecture notes
The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

Literature
The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Prerequisites / notice

227-0311-00L
Qubits, Electrons, Photons

Abstract
In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis).

Objective
Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Content
Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

In this way, students will work out a robust quantum mechanics (theoretical!!!) basis which will help them in their advanced studies of the following masters: EEIT (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.

IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing!).

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Literature


Supplementary material will be uploaded in Moodle.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!
A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET "Physics II".

Prerequisites / notice

Undergraduate physics, mathematics, semiconductor devices

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Nano-Optics

Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Objective

Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.
We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

**Prerequisites / notice**
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

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<thead>
<tr>
<th>Code</th>
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<th>credits</th>
<th>V+U</th>
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<tr>
<td>227-1635-00L</td>
<td>Electric Circuits</td>
<td></td>
<td>4</td>
<td>3G</td>
<td>D. Shchetinin</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to analysis methods and network theorems to describe operation of electric circuits. Theoretical foundations are essential for the analysis of the electric power transmission and distribution grids as well as many modern technological devices – consumer electronics, control systems, computers, and communications.

**Objective**
At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyse simple electric circuits with RLC elements, apply circuit theorems to simple meshed circuits, analyze AC circuits in a steady state and understand the connection of the explained principles to the modelling of the 3-phase electric power systems.

**Content**
Course will introduce electric circuits variables, circuit elements (resistive, inductive, capacitive), resistive circuits and theorems (Kirchhoff's laws, Norton and Thévenin equivalents), nodal and mesh analysis, superposition principle; it will continue by discussing the complete response circuits (RLC), sinusoidal analysis – ac steady state (complex power, reactive, active power) and conclude with the introduction to 3-phase analysis; Mathematical foundations of the circuit analysis, such as matrix operations and complex numbers will be briefly reviewed.

This course is targeting students who have no prior background in electrical engineering.

**Literature**
Richard C. Dorf, James A. Svoboda
Introduction to Electric Circuits, 9th Edition
Online materials: [https://www.wileyplus.com/](https://www.wileyplus.com/)
Lecture notes and exercises slides

<table>
<thead>
<tr>
<th>Code</th>
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<th>W</th>
<th>credits</th>
<th>V+U</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>327-0505-00L</td>
<td>Surfaces, Interfaces and their Applications I</td>
<td></td>
<td>3</td>
<td>2V+1U</td>
<td>N. Spencer, M. P. Heuberger, L. Isa</td>
</tr>
</tbody>
</table>

**Abstract**
After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

**Objective**
To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

**Content**
Introduction to Surface Science
Physical Structure of Surfaces
Surface Forces (static and dynamic)
Adsorbates on Surfaces
Surface Thermodynamics and Kinetics
The Solid-Liquid Interface
Electron Spectroscopy
Vibrational Spectroscopy on Surfaces
Scanning Probe Microscopy
Introduction to Tribology
Introduction to Corrosion Science

**Literature**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>W</th>
<th>credits</th>
<th>V+U</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>327-0703-00L</td>
<td>Electron Microscopy in Material Science</td>
<td></td>
<td>4</td>
<td>2V+2U</td>
<td>S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze</td>
</tr>
</tbody>
</table>

**Abstract**
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Objective**
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Content**
This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

**Lecture notes**
will be distributed in English
Solid State Physics and Chemistry of Materials I

Abstract
In this course we study how the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions.

Objective
Electronic properties and band theory description of conventional solids

Content
In this course we study how the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions. We begin with a review of the successes of band theory in describing many properties of metals, semiconductors and insulators, and we practise building up band structures from atoms and describing the resulting properties. Then we explore classes of systems in which the coupling between the electrons and the lattice is so strong that it drives structural distortions such as Peierls instabilities, Jahn-Teller distortions, and ferroelectric transitions. Next, we move on to strong couplings between electronic charge and spin-and/or orbital- angular momentum, yielding materials with novel magnetic properties. We end with examples of the complete breakdown of single-particle band theory in so-called strongly correlated materials, which comprise for example heavy-fermion materials, frustrated magnets, materials with unusual metal-insulator transitions and the high-temperature superconductors.

Lecture notes
An electronic script for the course is provided in Moodle.

Literature
Hand-outs with additional reading will be made available during the course and posted on the moodle page accessible through MyStudies all of:
- Statistical Thermodynamics (327-0315-00)
- Quantenmechanik für Materialwissenschaftler/innen (327-0316-00)
- Festkörpertheorie für Materialwissenschaftler/innen (327-0416-00)
- Electronic, Optical and Magnetic Properties of Materials (327-0512-00)
or equivalent classes from another institution

Complex Materials I: Synthesis & Assembly

Abstract
Introduction to materials synthesis concepts based on the assembly of differently shaped objects of varying chemical nature and length scales

Objective
The aim is a) to learn how to design and create objects as building blocks with a particular composition, size and shape, b) to understand the chemistry that allows for the creation of such hard and soft objects, and c) to master the concepts to assemble these objects into materials over several length scales.

Content
The course is divided into two parts: I) synthesis of 0-, 1-, 2-, and 3-dimensional building blocks with a length scale from nm to μm, and II) assembly of these building blocks into 1-, 2- and 3-dimensional structures over several length scales up to cm. In part I, various methodologies for the synthesis of the building blocks will be discussed, including Turkevich and Brust-Schiffrin-method for gold nanoparticles, hot-injection for semiconducting quantum dots, aqueous and nonaqueous sol-gel chemistry for metal oxides, or gas- and liquid-phase routes to nano structures. Part II is focused on self- and directed assembly methods that can be used to create higher order architectures from those building blocks connecting the microscopic with the macroscopic world. Examples include photonic crystals, nanocrystal solids, colloidal molecules, mesocrystals or particle-based foams and aerogels.

Literature
References to original articles and reviews for further reading will be provided on the lecture notes.

Multifunctional Ferroic Materials: Growth and Characterisation

Abstract
The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed.

Objective
Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

Content
Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

Scattering Techniques for Material Characterization

Abstract
All enrolled students are initially placed on the 'waiting list' until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.

The lecture presents the currently most efficient experimental techniques for microstructure material characterization: X-ray diffraction (XRD) and transmission electron microscopy (TEM). The theoretical basics, instrumentenation, complementarity and exclusivity of both techniques will be taught. The course includes practical elements and examples of current research projects at D-MATL.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 784 of 2416
Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to micro/nanotechnology and microfluidics. This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The main objective of this hands-on practical course is to give students a comprehensive insight into the most important aspects of microstructure characterization using electron and X-ray scattering. The focus is on the complementarity and exclusivity of the two techniques. We will introduce the most important material characterization tasks, present the relevant physical and crystallographic fundamentals, and discuss how the tasks can be solved with electron and X-ray scattering. We will discuss intrinsic and extrinsic advantages and limitations of the methods and explain essential instrumentation requirements specific to each setup. Another essential facet of the course is the link to everyday D-MATL project problems presented by the lecturers or researchers from D-MATL. The lecture is accompanied by hands-on experiments on samples of D-MATL projects using state-of-the-art instruments.

The objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course why it matters

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The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

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- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
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Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Techniques and Technologies</td>
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<tr>
<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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</table>

402-0317-00L Semiconductor Materials: Fundamentals and Fabrication

W 6 credits 2V+1U S. Schön, W. Wegscheider

Abstract
This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective
Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing

Content
1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes https://moodle-app2.let.ethz.ch/course/view.php?id=

Prerequisites / notice
The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

402-0402-00L Ultrafast Laser Physics

W 10 credits 3V+2U L. P. Gallmann, S. Johnson, U. Keller

Abstract
Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.

Objective
Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.
The lecture covers the following topics:

a) Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product

b) Dispersion compensation: technologies for controlling dispersion, pulse shaping, measurement of dispersion

c) Nonlinear pulse propagation: intensity-dependent refractive index (Kerr effect), self-phase modulation, nonlinear pulse compression, self-focusing, filamentation, nonlinear Schrödinger equation, solitons, non-instantaneous nonlinear effects (Raman/Brillouin), self-steepening, saturable gain and absorption

d) Second-order nonlinearities with ultrashort pulses: phase-matching with short pulses and real beams, quasi-phase matching, second-harmonic and sum-frequency generation, parametric amplification and generation

e) Relaxation oscillations: dynamical behavior of rate equations after perturbation

f) Q-switching: active Q-switching and its theory based on rate equations, active Q-switching technologies, passive Q-switching and theory

g) Active modelocking: introduction to modelocking, frequency comb versus axial modes, theory for various regimes of laser operation, Haus master equation formalism

h) Passive modelocking: slow, fast and ideally fast saturable absorbers, semiconductor saturable absorber mirror (SESAM), designs of and materials for SESAMS, modelocking with slow absorber and dynamic gain saturation, modelocking with ideally fast saturable absorber, Kerr-lens modelocking, soliton modelocking, Q-switching instabilities in modelocked lasers, inverse saturable absorption

i) Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more

j) Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection

k) Ultrafast measurements: pump-probe scheme, transient absorption/differential transmission spectroscopy, four-wave mixing, optical gating and more

l) Frequency combs and carrier-envelope offset phase: measurement and stabilization of carrier-envelope offset phase (CEP), time and frequency domain applications of CEP-stabilized sources

m) High-harmonic generation and attosecond science: non-perturbative nonlinear optics / strong-field phenomena, high-harmonic generation (HHG), phase-matching in HHG, attosecond pulse generation, attosecond technology: detectors and diagnostics, attosecond metrology (streaking, RABITT, transient absorption, attoclock), example experiments

n) Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications

o) Brief introduction to other hot topics: relativistic and ultra-high intensity ultrafast science, ultrafast electron sources, free-electron lasers, etc.

Literature

- G. Gryning, A. Aspect and C. Fabre, Introduction to Quantum Optics
- R. Loudon, The Quantum Theory of Light
- Atomic Physics, Christopher J. Foot
- Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
- C. Cohen-Tannoudji et al., Atom-Photon-Interactions
- M. Scully and M.S. Zubairy, Quantum Optics
- Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

402-0442-00L Quantum Optics W 10 credits 3V+2U A. Imamoglu

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Prerequisites / notice</th>
<th>Fostered competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class notes will be made available.</td>
<td>Prerequisites: Basic knowledge of quantum electronics (e.g., 402-0275-00L Quantenelektronik).</td>
<td>Subject-specific Competencies</td>
</tr>
</tbody>
</table>

402-0447-00L Quantum Science with Superconducting Circuits W 6 credits 2V+1U A. Wallraff, J.-C. Besse, C. Hellings

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected book chapters will be distributed.</td>
<td>Text-books:</td>
</tr>
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<td>- G. Gryning, A. Aspect and C. Fabre, Introduction to Quantum Optics</td>
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</tbody>
</table>
The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these materials, enabled
Mostly the original articles, other useful reading can be found in:
This course presents a comprehensive discussion of optical processes in semiconductors.
relevant publications will be cited
Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of
2V+1U
G. Scalari
- Apply concepts of quantum-mechanics to estimate the strength of atomic magnetic moments and their interactions
- Identify the mechanisms from which exchange interaction originates in solids (itinerant and local-moment magnetism)
- Evaluate the consequences of the interplay between competing interactions and thermal energy
- Discriminate the dynamic responses of a magnet to different external stimuli

Prerequisites: Quantum Mechanics I, Introduction to Solid State Physics
- G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press
- E. Rosencher and B. Vinter, Optoelectronics , Cambridge Univ. Press
- Strong light-matter coupling in Mid-IR and THz range
The lecture "Introduction to Magnetism" is a regular course of the Physics MSc program and aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what "being magnetic" means is essential to address this question properly. Theoretical concepts will be applied to few selected nano-sized magnets, which will serve as clean reference systems.

At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Preliminary contents for the HS21:
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field).
- Spin resonance and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)
- Magnetic order at finite temperatures (Ising and Heisenberg models, low-dimensional magnetism)
- Dipolar interaction in solids (shape anisotropy, origin of magnetic domains)

Lecture notes
Learning material will be made available through a dedicated RStudioServer and through Moodle.

Prerequisites / notice
Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

402-0595-00L
Semiconductor Nanostructures

W 6 credits 2V+1U T. M. Ihn

Objective
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Content
1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k-p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Lecture notes

Literature

Prerequisites / notice
The course is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving not assessed

Social Competencies
Communication not assessed
Self-presentation and Social Influence assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-direction and Self-management not assessed

529-0443-01L
Advanced Magnetic Resonance

W 6 credits 3G G. Jeschke, A. Barnes

Abstract
Does not take place this semester.

Objective
The course is for advanced students and covers selected topics from magnetic resonance spectroscopy. This semester, the lecture will introduce and discuss the dynamics of electron-nuclear spin systems and experiments based on hyperfine interactions in electron paramagnetic resonance (EPR) spectroscopy and dynamic nuclear polarization (DNP) for sensitivity enhancement in NMR.

The course aims at enabling students to understand and design experiments that are based on hyperfine coupling between electron and nuclear spins. This includes analytical and numerical treatment of spin dynamics as well as instrumental aspects. Additionally, students will learn how to use hyperfine couplings to increase sensitivity in solid state NMR via dynamic nuclear polarization (DNP), with an emphasis on the instrumentation required to perform DNP with magic angle spinning (MAS) NMR.
The course starts with a recapitulation of density operator and product operator formalism with special emphasis on electron-nuclear spin systems in the solid state. We then treat basic phenomena, such as passage effects, avoided level crossings, and hyperfine decoupling. Based on these foundations, we discuss polarization transfer from the electron to the nuclear spin and back, as well as spin diffusion as a mechanism for polarizing nuclear spins beyond the immediate vicinity of the electron spin. The second half of the course will cover dynamic nuclear polarization (DNP), with a focus on instrumentation required to perform pulsed DNP with magic angle spinning (MAS) at ultra-high magnetic fields. A review of salient interactions in the NMR solid state NMR Hamiltonian, DNP mechanisms, and electron decoupling with MAS will motivate discussions of technology development. Specific technologies to be covered include, but are not limited to, frequency agile gyrotron oscillators, corrugated waveguides, microwave lenses, strategies for creating pulsed and frequency chirped microwaves, spherical MAS rotors and supporting stators, high temperature superconductor (HTS) based compact magnets, and radio-frequency circuits for multinuclear spin control and detection.

Prerequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book “Spin Dynamics” by Malcolm Levitt.

Lecture notes
A script which covers the topics will be distributed in the lecture and will be accessible through the course Moodle

529-0455-00L Laser for Micro- and Nanostucturing W 2 credits 2V T. Lippert, N. Shepelin

Abstract
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, will be discussed together with industrial applications, such as microlithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Objective
Introduction to the fundamentals of lasers and their applications with an emphasis on micro- and nano-structuring. Several applications which are still in the research state, e.g. non-optical lithographies, will be discussed together with industrial applications, such as microlithography and laser welding. Other aspects are the materials that are applied in these applications, e.g. photoresists, and their functioning.

Content
Introduction to lasers, Overview of micro- and nanotechnology, microlithography, photoresists: classical types and new developments, laser cutting and welding, laser cleaning, laser ablation, polymer ablation: designed polymers, lasers and surfaces, laser spectroscopy, laser chemical vapor deposition, pulsed laser deposition (PLD), special materials by PLD, alternative structuring methods.

Lecture notes
The script (a copy of the slides) will be handed out during the first lecture.

Literature
FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.


Fostered competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed
- Analytical Competencies: not assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed
- Adaptable and Flexible: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

536-0103-00L Microtechnology W 4 credits 3G A. Hierlemann

Abstract
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the fabrication of mostly silicon-based microdevices and systems and related microfabrication processes.

Objective
Students are introduced to the basics of microtechnology, cleanroom, semiconductor and silicon process technologies. They will get to know the different fabrication methods for various microdevices and systems.

Content
Introduction to microtechnology, semiconductors, and micro electro mechanical systems (MEMS)
- Fundamentals of semiconductors and band model
- Fundamentals of devices: transistor and diode
- Silicon processing and fabrication steps
- Silicon crystal structure and manufacturing
- Thermal oxidation
- Doping via diffusion and ion implantation
- Photolithography
- Thin film deposition: dielectrics and metals
- Wet etching & bulk micromaching
- Dry etching & surface micromaching
- Microtechnological processing and fabrication sequence
- Optional: Packaging

Lecture notes
Handouts in English

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 790 of 2416
The lecture provides an overview on the behavior and effects of anthropogenic particles in the environment, covering engineered nanoparticles, micro/nanoplastics, tire wear, soot and pigments. The course will cover key concepts of particle behavior and analysis, fate in technical and natural systems, toxicity and environmental risk assessment and sustainability aspects and regulation.

Objective
- Successful application of knowledge gained in traditional disciplines of environmental sciences (e.g. biogeochemistry, environmental chemistry) to elucidate particle fate and behavior in the environment.
- Identify key parameters that potentially influence the environmental fate and behavior of anthropogenic particles.
- Get acquainted with the most common analytical tools for the quantification of anthropogenic particles in the environment.
- Critical assessment of current state of research, including the sometimes controversial literature data.

Content
- Definitions, particle types.
- Particle behavior: colloidal behavior, transport, transformation.
- Sources and release; Material flow modeling.
- Fundamentals of particle analysis.
- Release and emission.
- Fate in the environment: water, soil, air.
- Fate in technical systems: water treatment, waste incineration.
- Uptake and toxicity of particles.
- Environmental risk assessment.
- Life cycle assessment.

Lecture notes
Handouts will be provided.

Literature
Handouts will be provided during lecture.

Soft Materials (MaP Doctoral School)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-0213-00L</td>
<td>Fluid Dynamics with the Lattice Boltzmann Method</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>I. Karlin</td>
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</tbody>
</table>

Abstract
The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Objective
Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student’s choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
The course builds upon three parts:
I. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II. Theoretical basis of statistical mechanics and kinetic equations.
III. Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle’s distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Navier equation.
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; flows with phase transitions.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

Continuum Mechanics I
W 4 credits 2V+1U A. E. Ehret
Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.

Content
Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoelasticity, Examples of engineering applications, Comparison with experiments

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Bioelectronics and Biosensors
W 6 credits 2V+2U J. Vörös, M. F. Yanik
Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content
Lecture topics:

1. Introduction

Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)
Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed

327-0505-00L Surfaces, Interfaces and their Applications I W 3 credits 2V+1U N. Spencer, M. P. Heuberger, L. Isa

Abstract
After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

Objective
To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

Content
- Introduction to Surface Science
- Physical Structure of Surfaces
- Surface Forces (static and dynamic)
- Adsorbates on Surfaces
- Surface Thermodynamics and Kinetics
- The Solid-Liquid Interface
- Electron Spectroscopy
- Vibrational Spectroscopy on Surfaces
- Scanning Probe Microscopy
- Introduction to Tribology
- Introduction to Corrosion Science

Lecture notes
Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature
- Script Download: https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Prerequisites / notice
Chemistry: General undergraduate chemistry including basic chemical kinetics and thermodynamics
Physics: General undergraduate physics including basic theory of diffraction and basic knowledge of crystal structures

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed

Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed

327-1201-00L Transport Phenomena I W 5 credits 4G J. Vermant

Abstract
Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

Objective
The teaching goals of this course are on five different levels:
(1) Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling, ...
(2) Ability to use the fundamental concepts in applications
(3) Insight into the role of boundary conditions (mainly part 2)
(4) Knowledge of a number of applications.
(5) Flavor of numerical techniques: finite elements and finite differences.
Part 1 Approach to Transport Phenomena

Equilibrium Thermodynamics

Balance Equations

Forces and Fluxes

Applications

1. Measuring Transport Coefficients
2. Fluid mechanics
3. combined heat and flow

Lecture notes


Literature


Prerequisites / notice


Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Problem-solving

Method-specific Competencies

Abstract

In this course the engineering with soft materials is discussed. First, scaling principles to design structural and functional properties are introduced. Second, the characterisation techniques to interrogate the structure property relations are introduced, which include rheology, advanced optical microscopies, static and dynamic scattering and techniques for liquid interfaces.

Objective

The learning goals of the course are to introduce the students to soft matter and its technological applications, to see how the structure property relations depend on fundamental formulation properties and processing steps. Students should also be able to select a measurement technique to evaluate the properties.

Lecture notes

slides with text notes accompanying each slide are presented.

327-1207-00L Engineering with Soft Materials

W 5 credits 4G J. Vermant, L. Isa

Abstract

The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials.

Objective

The course first offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials. Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.

Content

This course is structured in 3 blocks:
- Block (I): Fundamentals of engineering in biological materials
  - Biological engineering principles
  - Basic building blocks found in biological materials
- Block (II): Replicating biological design principles in synthetic materials
  - Biological and bio-inspired materials: polymer-reinforced and ceramic-toughened composites
  - Lightweight biological and bio-inspired materials
  - Functional biological and bio-inspired materials: surfaces, self-healing and adaptive materials
- Block (III): Bio-inspired design and systems
  - Mechanical actuation - plant systems
  - Bio-inspiration in the built environment

Literature

Copies of the slides will be made available for download before each lecture.

327-1221-00L Biological and Bio-Inspired Materials

W 4 credits 3G A. R. Studart, I. Burgert, R. Nicolosi Libanori, G. Panzarasa

Abstract

The course is mainly based on the books listed below. Additional references will be provided during the lectures.

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will foster students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various communities. They will learn about the specific challenges and what is currently sizzling in the respective frontiers.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.
Content

Starting with the fabrication and analysis of nanoparticle materials, we will transition to discussing biomedical nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

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<td>Micro/Nanotechnology and Microfluidics for Biomedical Applications</td>
<td>2</td>
<td>W</td>
<td>E. Delamarche</td>
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<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>4</td>
<td>W</td>
<td>K. Maniura, M. Rotting, M. Zenobi-Wong</td>
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Abstract

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

Content

Mostly formal lectures (2 x 45 min), with a few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the preparation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:

- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magneto-resistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20$ electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

376-1714-00L Biocompatible Materials

<table>
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<td>529-0004-01L</td>
<td>Classical Simulation of (Bio)Molecular Systems</td>
<td>6</td>
<td>W</td>
<td>P. H. Hünlenberger, J. Dolenc, S. Riniker</td>
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</table>

Abstract

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective

Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature

See: www.csms.ethz.ch/education/CSBMS
Introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data.

Subject-specific Competencies
- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed
Introduction to lasers, overview of micro- and nanotechnology, micro lithography, photore sist s: classical types and new developments, laser cutting and welding, laser cleaning, laser ablation, polymer ablation: designed polymers, lasers and surfaces, laser spectroscopy, laser chemical vapor deposition, pulsed laser deposition (PLD), special materials by PLD, alternative structuring methods.

The script (a copy of the slides) will be handed out during the first lecture.

FSRM, CD-ROM: An Introduction to the World of Microsystems, Neuchatel.

Fostered competencies

<table>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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529-0615-01L Biochemical and Polymer Reaction Engineering

**Abstract**

**Objective**
The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

**Content**
We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes. Kinetics of free-radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

**Lecture notes**
Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html
Additional handout of slides will be provided during the lectures.

**Literature**
H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

529-0837-01L Biomedical Fluidics Engineering

**Abstract**
Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

**Objective**
We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.
Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small Volume Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

11. Single Cell Analysis
    Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

Applications of microfluidic tools in cellular analysis, flow cytometry, enzymatic assays and single cell analysis.

Lecture notes

Content

551-0357-00L

Cellular Matters: From Milestones to Open Questions

W

4 credits

2S


Autumn Semester 2022

Page 799 of 2416
### Content

In the last decade a new kind of compartments within the cell, the so-called biomolecular condensates, have been observed. This discovery is radically changing our understanding of the cell, its organization and dynamics. The emerging picture is that the cytoplasm and nucleoplasm are highly complex fluids that can (meta)stably segregate into membrane-less sub-compartments, similarly to emulsions.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverages, on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

Each week the lecture will consist of:

1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.

2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

### Lecture notes

The presentations will be made available after the lectures.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

### Literature

The milestone papers will be provided in advance.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

### Fostered competencies

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### Social Competencies

| Communication                        | assessed |
|                                    |          |
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|                                    |          |
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### Personal Competencies

| Adaptability and Flexibility | not assessed |
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### Course details

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<td>R. Mezzenga, G. Nyström</td>
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<td>752-2314-00L</td>
<td>Physics of Food Colloids</td>
<td>W 3</td>
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<td>752-3021-00L</td>
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Notes will be handed out during the lectures.

Lecture notes literature: Provided in the lecture notes.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 800 of 2416
### Strength & Durability of Materials (MaP Doctoral School)

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<td>V.-A. Silvestru</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>The course gives an introduction to structural glass design and related façade engineering aspects. It will focus on the properties of the material glass and glass products, as well as on the structural design of glass elements and their supporting systems and connections.</td>
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<td><strong>Objective</strong></td>
<td>After successful completion of the course, students will be able to:</td>
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<tr>
<td>- Understand and apply the fundamentals of the material glass and glass products, the basic principles for using glass as a load-carrying building material for structural applications and the types of connections used for glass elements;</td>
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<td>- Recognize requirements for glass elements depending on their application area and choose the appropriate glass products and assemblies accordingly;</td>
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<td>- Structurally design out-of-plane loaded glass elements based on available standards, both by hand calculations and specific software applications;</td>
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<td>- Apply selected approaches for the structural design of in-plane loaded glass elements;</td>
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<td>- Select suitable supporting systems (post-and-beam façade, curtain wall, etc.) and connections (point fixings, brackets, etc.) for the glass elements and structurally design them.</td>
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<tr>
<td><strong>Content</strong></td>
<td>This course introduces civil engineering students to structural glass design and related façade engineering aspects. It aims to provide the students the knowledge required in engineering offices to design glass elements but at the same time, the necessary fundamentals for later performing research in this field. To achieve this, the course includes lectures, design exercises and a design project.</td>
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<tr>
<td>Lectures:</td>
<td>The lectures will cover the following contents:</td>
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<tr>
<td>- Production methods and properties of the material glass and glass products and their structurally relevant properties (annealed glass, thermally tempered glass, chemically tempered glass, laminated glass, insulating glass, curved glass);</td>
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<tr>
<td>- Connection principles and types for glass elements (mechanical fixing, adhesive bonding);</td>
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<td>- Requirements for glass elements depending on the application area (vertical glazing, overhead glazing, walk-on glazing, barrier glazing);</td>
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<tr>
<td>- Structural design of glass elements based on standards and research results (out-of-plane loaded glass elements and in-plane loaded glass elements);</td>
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<td>- Typologies and design of structural systems for transparent façades;</td>
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<tr>
<td>- Requirements and functions for transparent façades.</td>
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<tr>
<td>Design exercises:</td>
<td>The principles and methods presented in the lectures are practiced with the students in design exercises. Hand calculation methods and their limitations as well as the software for structural glass design SJ Mepla are used for out-of-plane loaded glass elements. For in-plane loaded glass elements, the specifics of numerical calculation procedures are exemplified with the software Abaqus.</td>
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<tr>
<td>Design project:</td>
<td>The students will consolidate the knowledge gained in the theory-lectures and in the design exercises by working on a small design task (e.g. a glass canopy, a glass façade, a glass pavilion) in the form of a group work (ideally groups of 2-3 students). Within this task, the students will: conceptually design the structure and selected connection details; identify requirements for the glass elements and define their application-dependent selected glass components, their support systems and their connections. The students will work on the design task in the second half of the semester and will get feedback on their progress in weekly review sessions. At the end of the semester, the groups will submit a project report and give an oral presentation of their projects.</td>
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<tr>
<td>Lecture notes</td>
<td>The lectures are based on lecture slides and handouts.</td>
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<tr>
<td>Literature</td>
<td>Recommended and supplementary literature:</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prior knowledge of structural analysis, especially steel structures is necessary. Prior basic knowledge on the method of finite elements is recommended.</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0121-00L</td>
<td>Fatigue and Fracture in Materials and Structures</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>A. Taras</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>In this course, the students will learn:</td>
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<td>- Linear elastic and elastic-plastic fracture mechanics.</td>
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<td>- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.</td>
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<td>- Laboratory fatigue and fracture tests on details with cracks.</td>
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</table>
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- Linear elastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and "Laboratory Competition". The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- "Laboratory Competition" at Empa: the students with the closest predictions will win the "Empa Laboratory Competition" and will be awarded by a prize.

Lecture notes
Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Literature

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

101-0127-00L Advanced Structural Concrete

Abstract
This course supplements the courses Structural Concrete I and II regarding the analysis and dimensioning of reinforced and prestressed concrete structures. It focuses on limit analysis methods for girders, discs, slabs and shells, particularly regarding their applicability to the safety assessment of existing structures and their computer-aided implementation.

Objective
Within this course, the students are able to:
- deepen their understanding of structural concrete models and apply them to general design problems, including the assessment of existing structures.
- enhance their knowledge about the load-deformation response of reinforced and prestressed concrete structures.
- identify and assess the limits of applicability of limit analysis methods.
- recognize the assumptions of models suitable for computer-aided structural design and use in a critical way structural concrete design software.
- evaluate the long-term behaviour and the behaviour under fire conditions of concrete structures.
- assess the behaviour of fibre reinforced concrete structures.

Content
Fundamentals (structural analysis, theorems of limit analysis, applicability of limit analysis methods); shear walls and girders (stress fields and truss models, deformation capacity, membrane elements with yield conditions and load-deformation behaviour, computer-aided structural design); slabs (equilibrium solutions, yield conditions, shear and punching shear); fibre reinforced concrete (mechanical behaviour, applications); long term effects; fire behaviour.

Lecture notes
Lecture notes see: http://www.concrete.ethz.ch

Literature
101-0129-00L Non Destructive Evaluation & Rehabilitation of Existing Structures

**Abstract**
Introduction to non-destructive evaluation tools and quantitative structural analyses and verifications for condition assessment of existing structures and subsequent decisions on their rehabilitation.

**Objective**
The goal is for students to familiarize themselves with the handling of assessment and rehabilitation of existing structures from the perspective of a consulting engineer, following a systematic approach as described in current codes and to further learn how to use new non-destructive evaluation technologies.

**Content**
This course is organized in two main pillars. The first pillar describes the technologies that are available for non-destructive evaluation of structures and delves into description of the principle of operation of such methods (e.g. wave propagation, acoustic emission analysis, tomography). The second pillar, overviews the current implementation of condition assessment processes in codes and standards. Complementary to the topic of structural evaluation, the topic of interventions, rehabilitation and retrofitting of existing structures for different construction materials is next addressed.

**Lecture notes**
Lecture notes

**Literature**
Swiss Standards SIA 266, 269/1 to 269/7
SIA-Document D 0239 « Existing Structures – Introduction » (in German/French)
SIA-Document D 0239 « Existing Structures – Consolidation and Practice » (in German/French)
A. Costa, A. Arêde, H. Varum, Strengthening and Retrofitting of Existing Structures, Springer, 339p, 2018

**Assessed competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Personal Competencies</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</table>

Fostered competencies

101-0137-00L Steel Structures III: Advanced Steel and Composite Structures

**Abstract**
Expand the theoretical background and practical knowledge in the design of steel and composite structures. Special composite construction and detailing: partial connection, serviceability. Fire design. Cold-formed steel design. Crane girders; masts; tanks & silos. Structural glazing and lightweight cable-supported structures.

**Objective**
In Steel Structures III, students will deepen and expand their theoretical background and practical knowledge of the design and construction of steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. Students will learn how to solve complex structural engineering tasks in larger building projects, e.g. through the use and correct design of large-span slim-floor girders and ultra-slender composite columns, or the use of glazing and cable structures as principal load-carrying components. They learn how steel structures behave under fire conditions and how they can be protected and designed accordingly. Finally, students learn about the fundamental aspects governing the design of specialty steel structures, such as thin-walled cold-formed sections, crane girders, masts and storage tanks.

The examples of scientific and standardisation work provided in the lectures give the students the opportunity to learn about the most current developments and see how these are used to shape the future practice in the structural engineering field.

**Content**
Steel Structures III provides in-depth theoretical background and practical knowledge on advanced design topics in steel and composite structures. The focus of the course lies on design tasks and solutions in modern, multi-storey, steel-framed buildings driven by architectural needs, as well as on certain special fields of application of steel structures. The course discusses the use and design of large-span slim-floor girders and ultra-slender composite columns, as well as the use of glazing and cable structures as principal load-carrying components. The design of steel structures under elevated temperatures (fire conditions) is treated, as well as special topics of design for serviceability. In addition, fundamental concepts of the design of cold-formed steel framed structures are discussed. Finally, the course will give an overview on the design of specialty steel structures, such as crane girders, masts and storage tanks.

**Lecture notes**
Slides and lecture notes. Worked examples. Handouts and formula collections.

**Literature**
Stahlbaukalender (various editions), Ernst + Sohn, Berlin

**Prerequisites**
Prerequisites: Steel Structures I and II

101-0159-00L Method of Finite Elements II

**Abstract**
The Method of Finite Elements II is a continuation of Method of Finite Elements I. Here, we explore the theoretical and numerical implementation concepts for the finite element analysis beyond the linear elastic behavior. This course aims to offer students with the skills to perform nonlinear FEM simulations using coding in Python.

*This course offers no introduction to commercial software.*
This class overviews advanced topics of the Method of Finite Elements, beyond linear elasticity. Such phenomena are particularly linked to excessive loading effects and energy dissipation mechanisms. Their understanding is necessary for reliably computing structural capacity. In this course, instead of blindly using generic structural analysis software, we offer an explicit understanding of what goes on behind the curtains, by explaining the algorithms that are used in such software.

The course specifically covers the treatment of the following phenomena:
- Material Nonlinearity (Plasticity)
- Geometric Nonlinearity (Large Displacement Problems)
- Nonlinear Dynamics
- Fracture Mechanics

The concepts are introduced via theory, numerical examples, demonstrators and computer labs in Python (starting Fall 2021).

Upon completion of the course, the participants will be able to:
- Recognize when linear elastic analysis is insufficient
- Solve nonlinear dynamics problems, which form the core for limit state calculations (e.g. ultimate capacity, failure) of structures
- Numerically simulate fracture; a dominant failure phenomenon for structural systems.

See the class webpage for more information:

Lecture notes
The course slides serve as Script. These are openly available on: http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

Course Slides (Script): http://www.chatzi.ibk.ethz.ch/education/method-of-finite-elements-ii.html

Useful (optional) Reading:

Prerequisites / notice
- A good knowledge of Python is necessary for attending this course.

Fostered competencies

Subject-specific Competencies: 
Concepts and Theories assessed

Method-specific Competencies: 
Analytical Competencies assessed

Social Competencies: 
Cooperation and Teamwork assessed

Personal Competencies: 
Creative Thinking assessed

Critical Thinking assessed

101-0167-01L Fibre Composite Materials in Structural Engineering W 3 credits 2G M. Motavalli

Abstract
1) Lamina and Lamine Theory
2) FRP Manufacturing and Testing Methods
3) Design and Application of Externally Bonded Reinforcement to Concrete, Timber, and metallic Structures
4) FRP Reinforced Concrete, All FRP Structures
5) Measurement Techniques and Structural Health Monitoring

Objective
At the end of the course, you shall be able to

1) Design advanced FRP composites for your structures,
2) To consult owners and clients with necessray testing and SHM techniques for FRP structures,
3) Continue your education as a phd student in this field.

Content
Fibre Reinforced Polymer (FRP) composites are increasingly being used in civil infrastructure applications, such as reinforcing rods, tendons and FRP profiles as well as wraps for seismic upgrading of columns and repair of deteriorated structures. The objective of this course is on one hand to provide new generation of engineering students with an overall awareness of the application and design of FRP reinforcing materials for internal and external strengthening (repair) of reinforced concrete structures. The FRP strengthening of other structures such as metallic and timber will also be shortly discussed. On the other hand the course will provide guidance to students seeking additional information on the topic. Many practical cases will be presented analysed and discussed. An ongoing structural health monitoring of these new materials is necessary to ensure that the structures are performing as planned, and that the safety and integrity of structures is not compromised. The course outlines some of the primary considerations to keep in mind when designing and utilizing structural health monitoring technologies. During the course, students will have the opportunity to design FRP strengthened concrete beams and columns, apply the FRP by themselves, and finally test their samples up to failure.

Lecture notes
Power Point Presentations available online at www.empa.ch/abt303

Literature


3) fib bulletin 19, Externally applied FRP reinforcement for concrete structures, technical report, 2019


101-0527-10L Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction

W 3 credits 2G G. Habert, M. Posani

Abstract
Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction
Objective
Special focus on regenerative materials: earth, bio-based and reuse
The students will acquire knowledge in the following fields:
- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope: - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
  - Insulating materials (bio-based vs conventional)
  - Air barrier, vapour barrier and sealants
  - Interior finishing
- Assessment of materials and components behaviour and performance
- Solutions for energy retrofitting of (historical) buildings
- Aspects of sustainability and durability

Content
- Introduction to sustainability
- Sustainable cement and concrete
- Earth construction
- Visit
- Steel and bamboo
- Timber construction
- Building physic and conventional insulation
- Bio-based insulation
- Finishing
- Reuse

101-0617-01L Advances in Building Materials
Abstract
The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

Objective
In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

Content
The following topics are covered:
1. Material selection
2. Materials and sustainability 1
3. Materials and sustainability 2
4. Recyclability
5. Material science of wood durability
6. Material science of concrete durability
7. Foams in construction and thermal insulation
8. Sealants and adhesives in construction
9. Coatings
10. Flame retardants
11. Future of wood – 1
12. Future of wood – 2
13. Future of concrete – 1
14. Future of concrete – 2

Lecture notes
Handouts will be provided for each lecture.

101-0617-02L Computational Science Investigation for Material Mechanics
Abstract
Introduction to computational sciences with focus on numerical modeling of the mechanics of materials. Simulation of material damage, fracture and failure with various material models.

Objective
Learning from mistakes and failures is as old as the engineering discipline. Understanding why things went wrong is essential for improvement, but often impossible without the help of numerical modelling. Real world problems are often highly nonlinear, dependent on multiple physical fields, involve fundamental material behavior far from equilibrium and reversibility, and can only often be understood by addressing different relevant scales.

In this course, we will use real-life cases to learn how to deal with such problems. Starting from the problem description with governing equations, you will learn how to tackle non-linear and multi-field problems using numerical simulations. A particular focus will be on fracture. We will investigate the conditions and mechanisms that lead to material failure and analyze the contributions of plastic behavior, size effects, randomness in the underlying material micro-structure, and various other non-linear material behavior. You will learn various approaches to model the mechanics of complex heterogeneous materials and to implement your model in Python code to run numerical simulations.

Content
1 Introduction to (numeric) forensic engineering
2 The nature of engineering problems (governing equations)
3 Numerical recipes for dealing with non-linear problems
4 Multi-field problems (HTM)
5 On the nature of failure - Physics of damage and fracture
6 Cracks and growth in structures (LEFM and beyond)
7 Introduction to metal plasticity
8 Damage and fracture in heterogeneous materials
9 Mechanics of fatigue
10 Visco-elastic failure
11 Student -Project presentation

Lecture notes
Will be provided during the lecture via moodle.

Literature
Will be provided during the lecture.
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Personal Competencies</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-direction and Self-management</td>
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<tr>
<th>101-0639-01L Science and Engineering of Glass and Natural Stone in Construction</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
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</table>

**Abstract**
The course offers an overview of relevant practical issues and present technological challenges for glass and natural stones in constructions. Students gain a good knowledge of the basics of glasses and natural stones, their potential as engineering materials and learn to apply them in the design of civil engineering constructions and to evaluate concepts.

**Objective**
Glass is increasingly used in constructions to ease the construction process, as functional insulation barrier, even for structural applications of impressive size. While everyone has experienced the innovation potential of glass in the last decade, products from natural stone suffer from an unjustified traditional image that often originates from a lack of understanding of the material and its combination with other materials. Culturally important structures often are made from natural stone and their conservation demands an understanding of their deterioration mechanisms, the concepts of which can be applied to other civil engineering materials. Designers and engineers need the knowledge to reconcile materials and system behavior with the entire processing, handling, integration and life time in mind.

In this module students are provided with a broad fundamental as well as practice-oriented education on glass and natural stone in civil engineering applications. Present and future construction and building concepts demand for such materials with optimized properties. Based on the fundamentals from the Bachelor course in materials by the end of this module, you should be able to:

- recognize and choose specific applications from the broad overview you were provided with,
- relate processing technologies to typical products and building applications and recognize (and explain typical damage related to wrong material choice or application,
- explain the nature of glassy and crystalline materials and interpret their physical behavior against this background,
- explain the major deterioration mechanisms in natural stone and how this relates to durability,
- analyze material combinations and appraise their application in future products as well as integration in existing constructions,
- summarize with appropriate guidance publications on a related topic in an oral presentation and short report.

**Content**

- **Lecture 1:** An introduction to science and engineering of glass and natural stone in construction (FW/TW)
- **Lecture 2:** Glass chemistry including historical development of glass composition, use of raw materials, melts, chemical stability and corrosion. (FW)
- **Lecture 3:** Geology and mineralogy of stones used in construction. Formation processes, chemistry, crystal structure. (TW)
- **Lecture 4:** Microscopic models for glassy materials. Physics of vitrification. From microscopic physical models to thermodynamics, rheology and mechanics of glassy materials. (FW)
- **Lecture 5:** Stone properties and behavior: microstructure, density, porosity, mechanical properties (TW)
- **Lecture 6:** Glass physics: Optical properties (transmission, reflection, emission, refraction, polarization and birefringence, testing methods); Mechanical properties (density, thermal, mechanical, electric properties, glass testing) (FW)
- **Lecture 7:** Stone properties and durability: transport, moisture and thermal cycling (TW)
- **Lecture 8:** Forming and processing of glass: (plate and molded glass, drawing, slumping, profiling etc.; Processing: Cutting, mechanical processing, tempering, gluing, bending, laminating of glass Surface treatments: coating, sputtering, enameling, printing, etching, chemical pre-stressing.) (FW)
- **Lecture 9:** Durability: Salt crystallization, freezing, biodeterioration (TW)
- **Lecture 10:** Glass products for civil engineering applications: (Molded glasses, fiber glass, foam glass, plate glass); construction glass (insulation glass, structural glass, protective glass, intelligent glass, codes); (FW)
- **Lecture 11:** Conservation: Consolidation, cleaning, and other treatments (TW).
- **Lecture 12:** Glass in constructions. (modelling, application and regulation, typical damage in glass) (FW)
- **Lecture 13:** Student presentations; exam questions (FW/TW)
- **Lab1:** Durability of natural stone (FW/TW)
- **Lab2:** Fracture of glass (FW/TW)

**Lecture notes**

- Lab2: Fracture of glass (FW/TW) will be handed out in the lectures.

**Literature**

- Werkstoffe II script (download via the IFB homepage). Rest will be handed out in the lectures

**Prerequisites / notice**

- Werkstoffe I/II of the bachelor studies or equivalent introductory materials lecture.
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<th>Subject-specific Competencies</th>
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<tr>
<th>101-0659-01L</th>
<th>Durability and Maintenance of Reinforced Concrete</th>
<th>W</th>
<th>4 credits</th>
<th>2V</th>
<th>U. Angst, Z. Zhang</th>
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### Abstract

We look at the durability of reinforced concrete structures, covering common deterioration processes such as reinforcement corrosion, frost damage, ASR, etc. The course spans the range from fundamental mechanisms to aspects of engineering practice. New methods and materials for preventative measures, condition assessment and repair techniques are treated. Examples from real cases are shown.

### Objectives

After this course you will have profound understanding about:

- the different mechanisms of deterioration of concrete structures, in particular reinforcement corrosion
- the relevant parameters affecting durability of reinforced concrete (cover depth, concrete quality, moisture, etc.)

Furthermore, you will know:

- current engineering approaches for durability design (according to standards) and their limitations
- refined models for enhanced durability design and service life predictions
- effective measures to improve durability (e.g. stainless steel reinforcement, concrete surface coatings, etc.)
- the particular durability challenges with post-tensioned structures and ways to overcome them (electrically isolated tendons)
- methods for inspection and condition assessment of existing, ageing structures (including non-destructive techniques and monitoring with sensors)
- repair methods for deteriorated concrete structures such as conventional repair and electrochemical methods (in particular cathodic protection)
- possible future problems for durability that may arise with modern materials and construction technologies

### Content

- Socio-economic challenges related to ageing infrastructures
- Degradation mechanisms for concrete: sulphate attack, ASR, frost attack.
- Inspection and condition assessment: Chloride analyses, carbonation depth, etc. Non-destructive tests, particularly potential mapping to detect corrosion. New developments (for example, monitoring with sensors).
- Stainless steel as reinforcing steel for concrete: Different types of stainless steels. Coupling with black reinforcing steel. Examples of application. Life-cycle-costs.
- Modern materials and construction technologies: Discussion of expected implications for the durability of structures today and in the future.

### Excursion

- We generally try to organize a site-visit (depending on availability of construction sites). Presumably, we will visit an installation site of cathodic protection on a concrete structure in the Zurich area.

### Lecture notes

- Slides of the lectures will be distributed in advance
- Special handouts and reprints for particular topics will be distributed

### Literature

- Slides of the lectures will be distributed in advance
- Special handouts and reprints for particular topics will be distributed

### Prerequisites / notice

- The course is based on the book

- The course is a lecture that contains frequent discussion and interaction between students and lecturer. You will see and work on many examples from engineering practice, both during the lectures and in the form of exercises to be solved at home.

- Each student will work on a small case study and deliver a report during the semester. The report will be graded.
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**Concrete Technology**

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<th>101-0677-00L</th>
<th>Concrete Technology</th>
<th>W</th>
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F. Nägele, M. Bäuml, G. Martinola, T. Wangler

**Abstract**
Opportunities and limitations of concrete technology. Commodities and leading edge specialties.

**Objective**
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.

**Content**
Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:
- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as
  - self compacting concrete
  - fiber reinforced concrete
  - fast setting concrete
  - fair faced concrete
  - recycled concrete
- new research in digital fabrication with concrete

**Lecture notes**
Slides provided for download.

**Mechanics of Composite Materials**

<table>
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<th>151-0353-00L</th>
<th>Mechanics of Composite Materials</th>
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G. Pappas

**Abstract**
Focus is on laminated fibre reinforced polymer composites. The courses treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

**Objective**
To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

**Content**
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Thin ply composite shells & effects of material non-linearity

**Lecture notes**
Script, handouts, exercises and additional material are available in PDF-format on moodle page of the lecture.

**Literature**
The lecture material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced in there.

https://moodle-app2.let.ethz.ch/course/view.php?id=2610

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 808 of 2416
To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems of engineering applications, with particular focus on constitutive models.

The main objectives of this lecture are:

- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.

**151-0524-00L** *Continuum Mechanics I*

**Objective**
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

**Content**
Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments

**Lecture notes**
Slides of the lectures, relevant journal papers and user manuals will be provided.

**Fostered competencies**
- Concepts and Theories
- Techniques and Technologies

**151-0525-00L** *Dynamic Behavior of Materials*

**Objective**
Lectures and computer labs concerned with the modeling of the deformation response and failure of engineering materials (metals, polymers and composites) subject to extreme loadings during manufacturing, crash, impact and blast events.

**Content**
Topics include temperature and strain rate dependent elasto-plasticity, dynamic brittle and ductile fracture; impulse transfer, impact and wave propagation in solids; computational aspects of material model implementation; simulation of dynamic failure of structures;

**Lecture notes**
Slides of the lectures, relevant journal papers and user manuals will be provided.

**Prerequisites / notice**
Course in continuum mechanics (mandatory), finite element method (recommended)

**Fostered competencies**
- Concepts and Theories
- Techniques and Technologies

**151-0529-00L** *Computational Mechanics II: Nonlinear FEA*

**Objective**
The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity, kinematics (large deformations, instability problems) and boundary conditions (contact)).

**Content**
1. Introduction: various sources of nonlinearities and implications for FEA.

**Lecture notes**
Lecture notes will be provided. However, students are encouraged to take their own notes.

**Prerequisites / notice**
Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

**Fostered competencies**
- Concepts and Theories
- Techniques and Technologies

**151-0544-00L** *Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis*

**Abstract**
An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

**Objective**
The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.
Adaptive Materials for Structural Applications

W 4 credits 3G A. Bergamini

Abstract
Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated, also with laboratory experiments where possible.

Objective
The study of adaptive materials covers topics that range from chemistry to theoretical mechanics. The aim of this course is to convey knowledge about adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

Content
This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions. Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion


Thermo-mechanical coupling: Shape memory alloys / polymers

Electromechanical coupling(1): DEA, EBL, electrorheological fluids

Shape control / morphing: Use, requirements, challenges

Morphing applications of variable stiffness structures: Lab work

Electromechanical coupling (2): Piezoelectric, electrostrictive effect

Vibration Reduction: Measurement, passive, semi-active (active) damping methods

Vibration reduction applications of piezoelectric materials: Lab work

Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials

Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...
1. Introduction
Moisture damage: problem statement, durability
Applications: building materials, soil science, geoscience

2. Moisture transport: theory and application
Description of moisture transport
Determination of moisture transport properties
Exercises on moisture transport properties

3. Special topics
Liquid transport in cracked materials, Drying of porous materials, Microclimate in urban street canyons

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Literature
All material is provided online via Moodle.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Physics of Failure and Reliability of Electronic Devices and Systems

W 3 credits 2V
I. Shorubalko, M. Held

Abstract
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective
Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Literature

Composites and Hybrids: From Design to Application

New title as of HS22. Old title: Advanced Composite and Adaptive Material Systems

W 5 credits 3V+1U
F. J. Clemens, B. Weisse, A. Winstörfer

Abstract
Composites/hybrids are heterogeneous materials consisting of two or more bonded components, and it is possible to tailor material properties for certain applications. Typically, The components retain their structure and properties, but the properties of the composite are a combination of the properties of its components.

Objective
In this course you will get an inside to lightweight material with high strength, materials that are resistive against abrasion, ceramics with damage tolerance behavior, composites with bioactive, bioresorbable, piezoresistive and -electric properties. Enables materials scientists to design composite/hybrid materials for different applications. The course will comprise a balance of lectures, exercises and laboratory classes.

Content
Introduction and basic concepts on biomedical composites and smart composites/hybrids with sensing and actuation properties; production and properties of composites reinforced with particles, whiskers, short or long fibers; selection criteria, case studies and applications, future perspectives.

1. Structural composites (polymer-, metal- and ceramic matrix composites)
   1.1. Introduction and historical background
   1.2. Components: Matrix and reinforcement materials
   1.3. Types of composites and mechanisms of reinforcement
   1.4. Production processes
   1.5. Physical and chemical properties
   1.6. Applications

2. Biomedical Composites
   2.1. Introduction and historical background
   2.2. Components: metals&alloys, natural/synthetic polymers, bioceramics
   2.3. Types of biocomposites
   2.4. Production processes
   2.5. Properties
   2.6. Applications

3. Functional Composites (Sensors and Actuators)
   3.1. Introduction and historical background
   3.2. Components: Matrix and functional filler material
   3.3. Types of composites
   3.4. Production processes
   3.5. Properties
   3.6. Applications

Lecture notes
We will work with handouts
Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies not assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
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Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

376-0021-00L Materials and Mechanics in Medicine W 4 credits 3G M. Zenobi-Wong, J. G. Snedeker

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
- Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
- course website on Moodle

Literature

Sustainable & Bioinspired Materials (MaP Doctoral School)

Number Title Type ECTS Hours Lecturers
101-0527-10L Materials and Constructions W 3 credits 2G G. Habert, M. Posani

Abstract
Building materials with a special focus on regenerative materials: earth, bio-based and reuse.

Objective
- Special focus on regenerative materials: earth, bio-based and reuse
- The students will acquire knowledge in the following fields:
  - Fundamentals of material performance
  - Introduction to durability problems of building facades
  - Materials for the building envelope:
    - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
    - Insulating materials (bio-based vs conventional)
    - Air barrier, vapour barrier and sealants
    - Interior finishing
  - Assessment of materials and components behaviour and performance
  - Solutions for energy retrofitting of (historical) buildings
  - Aspects of sustainability and durability

Content
- Introduction
- Sustainable cement and concrete
- Earth construction
- Visit
- Steel and bamboo
- Timber construction
- Building physic and conventional insulation
- Bio-based insulation
- Finishing
- Reuse

101-0637-10L Wood Structure and Function W 3 credits 2G I. Burgert, G. von Arx

Abstract
The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general and species-specific relationships between growth processes, wood properties and wood function in the living tree.

Objective
- Number of participants limited to 15.
- The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general and species-specific relationships between growth processes, wood properties and wood function in the living tree.
- Learning target is a basic understanding of the anatomy of wood and the related impact of endogenous and exogenous factors. The students can learn how to distinguish common central European wood species at the macroscopic and microscopic level. A deeper insight will be given by wood identification exercises for softwood species. Further, the students will gain insight into the relationships between tree growth and wood properties with a specific focus on the wood function in the living tree.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 812 of 2416
### 102-0317-00L Advanced Environmental Assessments

**Prerequisites / notice**
- Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0317-00 Advanced Environmental Assessments (3 KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5 KP).

**Lecture notes / literature**
- Literature will be made available on Moodle.

**Prerequisites / notice**
- Before required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

### 151-0509-00L Acoustics In Fluid Media: From Robotics to Additive Manufacturing

**Prerequisites / notice**
- Solid and fluid continnum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

**Prerequisites / notice**
- Before required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).
Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments

**Lecture notes**

**227-0393-10L** Bioelectronics and Biosensors

**W** 6 credits  **2V + 2U**  J. Vörös, M. F. Yanik

**Abstract**
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectric signals and the basic concepts to record optogenetically modified organisms are introduced.

**Objective**
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

**Content**
Lecture topics:

1. Introduction

Sources of bioelectric signals

2. Membrane and Transport

3-4. Action potential and Hodgkin-Huxley

Measuring bioelectric signals

5. Detection and Noise

6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes

7. Measuring potentials in solution and core conductance model

8. Measuring electronic signals with wearable electronics, ECG, EEG

9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording

10. Functional electric stimulation

11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)

12. Measuring neurons optically, fundamentals of optical microscopy

13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

**Lecture notes**
A detailed script is provided to each lecture including the exercises and their solutions.

**Literature**
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

**Prerequisites / notice**
The course requires an open attitude to the interdisciplinary approach of bioelectronics.

In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

**Fostered competencies**

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**327-1101-00L** Biomineralization

**W** 2 credits  **2V**  K.-H. Ernst

**Abstract**
The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.
Biominalization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biominalization (BM)/types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-/intra-extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrate teeth and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biominalization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. silica
11. Iron storage and mineralization

Script with more than 600 pages with many illustrations will be distributed free of charge.

The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials.

The course first offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials. Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.

This course is structured in 3 blocks:
- Biological engineering principles
- Basic building blocks found in biological materials
- Replicating biological design principles in synthetic materials
- Lightweight biological and bio-inspired materials
- Functional biological and bio-inspired materials: surfaces, self-healing and adaptive materials
- Bio-inspired design and systems
- Mechancial actuation - plant systems
- Bio-inspiration in the built environment

The course is mainly based on the books listed below. Additional references will be provided during the lectures.


The course covers definition and general concepts of biomineralization (BM)/types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-/intra-extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrate teeth and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.
The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. MULTISCALE BONE BIOMECHANICS

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
Course website on Moodle

Literature

Number of participants limited to 30

Abstract
The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

Objective
The learning objectives include:
1. advanced knowledge of the state-of-the-are in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programing skills through the use of python;
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Content
Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions Courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the students may prepare additional teaching material to answer the posted questions (Q&A).

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

Lecture notes
Material will be provided on Moodle and eColab.

Prerequisites / notice
Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

Number of participants limited to 30

Abstract
This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

Objective
The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

Content
Mostly formal lectures (2 x 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore's law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beamers, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photons, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters

For the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 205 electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone

The 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

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Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

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817. Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

Objective
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

376-1714-00L Biocompatible Materials

Abstract
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

376-1974-00L Colloquium in Biomechanics

Abstract
Current topics in biomechanics presented by speakers from academia and industry.

Objective
Getting insight into actual areas and problems of biomechanics.


Objective
The aim of the course is to learn how to design polymerization reactors and bioreactors to produce polymers and proteins with the specific product qualities that are required by different applications in chemical, pharmaceutical and food industry. This activity includes the post-treatment of polymer latexes, the downstream processing of proteins and the analysis of their colloidal behavior.

Content
We will cover the fundamental processes and the operation units involved in the production of polymeric materials and proteins. In particular, the following topics are discussed: Overview on the different polymerization processes. Kinetics of free radical polymerization and use of population balance models. Production of polymers with controlled characteristics in terms of molecular weight distribution. Kinetics and control of emulsion polymerization. Surfactants and colloidal stability. Aggregation kinetics and aggregate structure in conditions of diffusion and reaction limited aggregation. Modeling and design of colloid aggregation processes. Physico-chemical characterization of proteins and description of enzymatic reactions. Operation units in bioprocessing: upstream, reactor design and downstream. Industrial production of therapeutic proteins. Characterization and engineering of protein aggregation. Protein aggregation in biology and in biotechnology as functional materials.

Lecture notes
Scripts are available on the web page of the Arosio-group: http://www.arosiogroup.ethz.ch/education.html
Additional handout of slides will be provided during the lectures.

Literature
H.W. Blanch, D. S. Clark, Biochemical Engineering, CRC Press, 1995

529-0837-01L Biomicrofluidic Engineering

Abstract
Microfluidics describes the behaviour, control and manipulation of fluids geometrically constrained within sub-uL environments. Microfluidic devices enable physical and chemical processes to be controlled with exquisite precision and in an fast and efficient manner. This course introduces the underlying concepts, features and applications of microfluidic systems in the chemical and life sciences.

Objective
We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological analysis.

Number of participants limited to 25.

A central component of this course is a research project. This will allow students to develop a practical understanding of the benefits of miniaturization in chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.
Specific topics covered in the course include, but are not limited to:

1. Theoretical Concepts
   Scaling laws, features of thermal/mass transport, diffusion, basic description of fluid flow in small volumes, microfluidic mixing strategies.

2. Microfluidic Device Manufacture
   Basic principles of conventional lithography of rigid materials, ‘soft’ lithography, polymer machining (injection molding, hot embossing, and 3D-printing).

3. Electrokinetics
   Principles of electrophoresis, electroosmosis, high performance capillary electrophoresis, electrokinetic scaling laws, chip-based electrophoresis and isoelectric focusing.

4. Mass Transfer Phenomena
   Key features of mass transport in microfluidic systems, diffusive transport, diffusion-convection, Péclet number, Taylor-Aris diffusion, chaotic mixing and Damköhler numbers.

5. Heat Transfer Phenomena
   Key features of thermal transport in microfluidic systems, conduction, convection, heat transfer by convection in internal flows, heat transfer processes in microfluidic devices.

6. Microfluidic Systems for Materials Synthesis
   Microfluidic reactors for the controlled synthesis of colloidal nanomaterials, advanced automation for bespoke materials discovery & characterization.

7. Point-of-Care Diagnostics
   Microscale tools for diagnostics, challenges associated with point-of-care (PoC) diagnostic testing, requirements for PoC devices, common PoC device formats, applications of PoC diagnostics in the developing world.

8. Microscale DNA Amplification
   Amplification and analysis of nucleic acids using batch, continuous flow and droplet-based microfluidic reactors.

9. Small volume Molecular Detection
   Spectroscopic approaches for analyte detection in small volumes with a particular focus on single molecule detection.

10. Droplets and Segmented Flows
    Formation, manipulation and use of liquid/liquid segmented flows in chemical and biological experimentation.

Lecture notes
Lecture handouts, background literature, problem sheets and notes will be provided electronically through the course Moodle site.

There is no set text for the course. All relevant literature will be provided electronically through the course Moodle site.

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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636-0104-00L  Biophysical Methods  4 credits  3G  D. J. Müller

Abstract
Students will be imparted knowledge in basic and advanced biophysical methods applied to problems in molecular biotechnology. The course is fundamental to applying the methods in their daily and advanced research routines. The students will learn the physical basis of the methods as well as their limitations and possibilities to address existing and future topics in molecular biotechnology.

Objective
Gain of interdisciplinary competence in experimental and theoretical research, which qualifies for academic scientific work (master's or doctoral thesis) as well as for research in a biotechnology or a pharmaceutical company. The module is of general use in courses focused on modern biomolecular technologies, systems biology and systems engineering.

Content
The students will learn basic and advanced knowledge in applying biophysical methods to address problems and overcome challenges in biotechnology, cell biology and life sciences in general. The biological and physical possibilities and limitations of the methods will be discussed and critically evaluated. By the end of the course the students will have assimilated knowledge on a portfolio of biophysical tools widening their research capabilities and aptitude.

The biophysical methods to be taught will include:
- Light microscopy: Resolution limit of light microscopy, fluorescence, GFP, fluorescence microscopy, DIC, phase contrast, difference between wide-field and confocal microscopy
  - Super resolution optical microscopy: STED, PALM, STORM, other variations
  - Electron microscopy: Scanning electron microscopy, transmission electron microscopy, electron tomography, cryo-electron microscopy, single particle analysis and averaging, tomography, sectioning, negative stain
  - X-ray, electron and neutron diffraction
  - MRI imaging
  - Scanning tunnelling microscopy and atomic force microscopy
- Patch clamp technologies: Principles of patch clamp analysis and application. Various patch clamp approaches used in research and industry
  - Surface plasmon resonance-based biosensors
  - Molecular pore-based sensors and sequencing devices
  - Mechanical molecular and cellular assembly devices
  - Optical and magnetic tweezers
  - CD spectroscopy
  - Optogenetics
  - Molecular dynamics simulations

Lecture notes
Hand out will be given to students at lecture.
### Transferable Skills

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-2226-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students (MaP Doctoral School)</td>
<td>E-Learning and Workshop</td>
<td>1 credit</td>
<td>2U</td>
<td>L. Schefer, S. Stepanov, M. Trassin</td>
</tr>
</tbody>
</table>

**Abstract**

The course sensitises doctoral students to ethical issues that may occur during their doctorate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a discipline specific context.

**Objective**

Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

**Content**

**Part I**

The self-paced e-learning course consists of 5 modules:

1. Ethics: Introduction to moral theory (with emphasis on practical guidance regarding decision making)
2. Ethics in Scientific Research: Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).
3. Collecting Resources: A variety of tools and resources that help identify ethical issues are presented and explained
4. Setting up a Strategy: Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).
5. Making Decisions: Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

**Part II**

The second, face-to-face part of this course focuses on discipline-specific aspects of Materials, Processes and Manufacturing Technologies. It provides an interactive learning environment. Participants get to apply their knowledge, and they are encouraged to reflect on ethical problems and critically discuss them with fellow doctoral students.

**Prerequisites / notice**

For doctoral students only

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<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days)</td>
<td>Only for doctoral students.</td>
<td>1 credit</td>
<td>2S</td>
<td>Lecturers</td>
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**Abstract**

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Objective**

Acquisition of transferrable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

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<td>900-0101-DRL</td>
<td>Transferable Skills Course II (1-3 days)</td>
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<td>1 credit</td>
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<td>900-0102-DRL</td>
<td>Transferable Skills Course III (1-3 days)</td>
<td>Only for doctoral students.</td>
<td>1 credit</td>
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<td>900-0103-DRL</td>
<td>Transferable Skills Course I (1-3 days, with Poster or Talk)</td>
<td>2</td>
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<tr>
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Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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<tr>
<th>Number</th>
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Language Courses ETH/UZH: see Science in Perspective
Educational Science for Teaching Diploma and TC

Integration into Scientific Community

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<tr>
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### External Conference I (incl. Poster or Talk)

- **900-0162-DRL**
- Only for doctoral students.
- **Abstract**: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **Objective**: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **W 1 credit 2K Lecturers**

### External Conference II (incl. Poster or Talk)

- **900-0163-DRL**
- Only for doctoral students.
- **Abstract**: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **Objective**: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **W 1 credit 2K Lecturers**

### External Conference III (incl. Poster or Talk)

- **900-0164-DRL**
- Only for doctoral students.
- **Abstract**: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **Objective**: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **W 1 credit 2K Lecturers**

### Doctorate Materials Science - Key for Type

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<td>O</td>
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<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

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<td>G</td>
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<td>U</td>
<td>exercise</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

### ECTS

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.

Subject Specialisation

The list of courses (together with the allocated credit points) eligible for doctoral students is published each semester in the newsletter of the ZGSM. www.zgsm.ch/index.php?id=260&type=2

Graduate School

Official website of the Zurich Graduate School in Mathematics: www.zurich-graduate-school-math.ch

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>401-5003-72L</td>
<td>A PDE Approach to Mean-Field Disordered Systems</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>J.-C. Mourrat</td>
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</tbody>
</table>

Abstract
Nachdiplom lecture

Content
The goal of statistical mechanics is to describe the large-scale behavior of collections of simple elements, often called spins, that interact through locally simple rules and are influenced by some amount of noise. We will discuss three classes of such models, of increasing difficulty, and will rely on a common PDE approach to study each of them.

The first model we will study is the very simple Curie-Weiss model, in which every spin interacts with every other spin and has a preference for being aligned with the others. This model can be solved in a variety of ways, but will be used to develop our toolkit based on the study of certain Hamilton-Jacobi equations that naturally arise.

We will then turn to a more challenging class of models coming from statistical inference. We will focus on a setup in which we observe a noisy version of a large rank-one matrix. We will compute the information-theoretic limit to the recovery of this matrix based on the PDE techniques introduced earlier.

We will finally discuss spin-glass models, in which the local interactions between the spins are disordered. One of the core motivations for the development of the techniques presented here is to uncover the behavior of models in which spins can be of different types, such as for instance when the spins are organized over two layers, and only have direct interactions across layers. While the understanding of this class of models is still very limited, I will present some progress towards this goal.

Prerequisites / notice
The prerequisites for these lectures are basic measure theory and probability theory. No prior knowledge of PDE theory will be assumed.

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<tbody>
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<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
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</table>

Abstract
The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.

Objective
Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content
Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdie's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

Prerequisites / notice
The prerequisites for this course are basic knowledge of linear algebra, analysis, and discrete mathematics.

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<tr>
<td>401-3055-64L</td>
<td>Algebraic Methods in Combinatorics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>B. Sudakov</td>
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Abstract
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to a linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the course will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice
Students are expected to have a mathematical background and should be able to write rigorous proofs.
This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.

**Objectives**

- Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods).
- Knowledge of methods and basic theory for high-dimensional statistical inference
- Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling
- Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.
- Interface between the frequentist and Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayesian models, empirical Bayes, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods).

**Prerequisites**

- Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

**Literature**


**Additional references**

- Additional references will be given in the course.
Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.

Classical statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.

Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons.

Identical quantum particles: many body wave functions, second quantization formalism, equation of motion, correlation functions, selected applications, e.g. Bose-Einstein condensate and coherent state, phonons in elastic media and melting.

One-dimensional interacting systems.

Phase transitions: mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls' arguments on long-range order.


Adaptability and Flexibility
L. Senatore

Lecture notes available in English.

Introduction to String Theory
Suggested textbooks:
- two-dimensional field theories (classical/quantum, conformal/non-conformal)
- supergravity as a low-energy effective theory, strings on curved backgrounds
- D-branes, T-duality
- string modes and their quantisation; higher dimensions, supersymmetry
- supergravity as a low-energy effective theory, strings on curved backgrounds
- two-dimensional field theories (classical/quantum, conformal/non-conformal)
### Prerequisites / notice

**252-0417-00L**  
**Randomized Algorithms and Probabilistic Methods**  
W 10 credits  3V+2U+4A  A. Steger

**Abstract**  
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

**Objective**  
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

**Content**  
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

**Literature**


**Lecture notes**

Yes.

**Course material Script, computer demonstrations, exercises and problem solutions**

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**227-0447-00L**  
**Image Analysis and Computer Vision**  
W 6 credits  3V+1U  E. Konukoglu, F. Yu

**Abstract**  

**Objective**  
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content**  
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Lecture notes**

Course material Script, computer demonstrations, exercises and problem solutions

**Prerequisites / notice**

Prerequisites:  
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

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**227-0417-00L**  
**Information Theory I**  
W 6 credits  4G  A. Lapidoth

**Abstract**  
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

**Objective**  
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

**Content**  
The entropy rate of a source. Typical sequences, the asymptotic equi-partition property, the source coding theorem, the channel coding theorem, the source-channel separation theorem, feedback capacity.

**Literature**

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

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**227-0423-00L**  
**Neural Network Theory**  
W 4 credits  2V+1U  H. Bölcskei

**Abstract**  
Does not take place this semester.

**Objective**  
The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

**Content**  
1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

**Lecture notes**

Detailed lecture notes are available on the course web page  
https://www.mins.ee.ethz.ch/teaching/mnt/

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**151-0563-01L**  
**Dynamic Programming and Optimal Control**  
W 4 credits  2V+1U  R. D’Andrea

**Abstract**  
Introduction to Dynamic Programming and Optimal Control.

**Objective**  
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**  
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.
**401-3225-DRL**  
*Introduction to Lie Groups*  
W 3 credits 4G  M. Burger  

Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0  

**Abstract**  
Topological groups and Haar measure. Definition of Lie groups, examples of local fields and examples of discrete subgroups; basic properties; Lie subgroups, Lie algebras and relation with Lie groups: exponential map, adjoint representation. Semisimplicity, nilpotency, solvability, compactness; Killing form, Lie's and Engel's theorems. Definition of algebraic groups and relation with Lie groups.  

**Objective**  
The goal is to have a broad though foundational knowledge of the theory of Lie groups and their associated Lie algebras with an emphasis on the algebraic and topological aspects of it.  

**Literature**  
A. Knapp: "Lie groups beyond an Introduction" (Birkhäuser)  
A. Sagle & R. Walde: "Introduction to Lie groups and Lie algebras" (Academic Press, '73)  
F. Warner: "Foundations of differentiable manifolds and Lie groups" (Springer)  
H. Samelson: "Notes on Lie algebras" (Springer, '90)  
S. Helgason: "Differential geometry, Lie groups and symmetric spaces" (Academic Press, '78)  

**Prerequisites / notice**  
Topology and basic notions of measure theory. A basic understanding of the concepts of manifold, tangent space and vector field is useful, but could also be achieved throughout the semester.  

Course webpage: https://metaphor.ethz.ch/x/2018/hs/401-3225-00L/  

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**401-3001-DRL**  
*Algebraic Topology I*  
W 3 credits 4G  S. Kalisnik Hintz  

Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0  

**Abstract**  
This is an introductory course in algebraic topology, which is the study of algebraic invariants of topological spaces. Topics covered include: singular homology, cell complexes and cellular homology, the Eilenberg-Steenrod axioms.  

**Literature**  
Book can be downloaded for free at: http://www.math.cornell.edu/~hatcher/AT/ATpage.html  
See also: http://www.math.cornell.edu/~hatcher/anchor1772800  
3) E. Spanier, "Algebraic topology", Springer-Verlag  
You should know the basics of point-set topology.  

Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course "topology").  

Some knowledge of differential geometry and differential topology is useful but not strictly necessary.  

Some (elementary) group theory and algebra will also be needed.  

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**401-3533-DRL**  
*Generalized Nonpositive Curvature*  
W 3 credits 3V  U. Lang  

Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0  

**Abstract**  
CAT(0) spaces, Busemann convex spaces, metric spaces with convex geodesic bicombings, injective metric spaces and injective hulls, Gromov hyperbolicity, Helly graphs and Helly groups.  

**Lecture notes**  
Lectures notes will be provided.  

**Literature**  
- A. Papadopoulos: Metric Spaces, Convexity and Nonpositive Curvature, EMS 2005  

**Prerequisites / notice**  
Basic knowledge of Riemannian geometry and functional analysis will be assumed.  

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**401-4657-DRL**  
*Numerical Solution of Stochastic Ordinary Differential Equations*  
W 3 credits 3V+1U  A. Stein  

Alternative course titles: "Numerical Analysis of Stochastic Ordinary Differential Equations" / "Computational Methods for Quantitative Finance: Monte Carlo and Sampling Methods"  

Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see
Abstract
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content
Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes
There will be English, typed lecture notes for registered participants in the course.

Literature

Prerequisites / notice
Prerequisites:
Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.
a) mandatory courses:
Elementary Probability, Probability Theory I.
b) recommended courses:
Stochastic Processes.

Start of lectures: Wednesday September 21, 2022.
Content

Prerequisites / notice
This is the course unit with former course title "Regression". Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

401-4623-DRL Time Series Analysis W 2 credits 2G N. Meinshausen

Abstract
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

Literature
The main reference for this course is the book “Introduction to Time Series and Forecasting”, by P. J. Brockwell and R. A. Davis

401-3612-DRL Stochastic Simulation W 2 credits 2V+1U F. Sigrist

Abstract
This course provides an introduction to stochastic Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

Objective
Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Content
- Examples of simulations in different fields (computer science, statistics, statistical mechanics, operations research, financial mathematics).

Lecture notes
A script will be available in English.

Literature

Prerequisites / notice
Basic knowledge in probability and statistics

401-4889-DRL Mathematical Finance W 3 credits 4V+2U D. Possamaï

Abstract
Advanced course on mathematical finance: - semimartingales and general stochastic integration - absence of arbitrage and martingale measures - fundamental theorem of asset pricing - option pricing and hedging - hedging duality - optimal investment problems - additional topics

Objective
Advanced course on mathematical finance, presupposing good knowledge in probability theory and stochastic calculus (for continuous processes)
1. Theory: In this course, we will discuss the trade-off between accuracy and stability of classification algorithms and study the state-of-the-art for robust image classification, adversarial attacks and adversarial training.

2. Practice: Students will train and attack deep neural networks themselves, to get a hands-on experience.

Topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imsf/education/education-in-stochastic-finance/overview-of-courses.html.

401-3054-DRL Probabilistic Methods in Combinatorics
Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0

Abstract
This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content
The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

401-4607-DRL Topics on the Gaussian Free Field
Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0

Abstract
We will discuss various aspects and properties of the Gaussian Free Field.

Content
Topics discussed will include:
- Discrete and continuous Gaussian Free Field
- Local sets.
- Relation to loop-soups.
- Uniform spanning trees.

401-4651-DRL Robustness of Deep Neural Networks
Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0

Abstract
While deep neural networks have been very successfully employed in classification problems, their stability properties remain still unclear. In particular, the presence of adversarial examples has demonstrated that state-of-the-art networks are vulnerable to small perturbations in the data. This course serves as an introduction to adversarial attacks and defenses for deep neural network algorithms.

Objective
1. Theory: In this course, we will discuss the trade-off between accuracy and stability of classification algorithms and study the state-of-the-art for robust image classification, adversarial attacks and adversarial training.
2. Practice: Students will train and attack deep neural networks themselves, to get a hands-on experience.

Prerequisites / notice
Courses on linear algebra, optimization and machine learning. Basic programming skills in Python, and experience with PyTorch or TensorFlow.

401-4597-DRL Random Walks on Transitive Graphs
Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0

Abstract
In this course, we will present modern topics at the interface between probability and geometric group theory. We will be mainly focused on the random walk, and discuss its behavior depending on the geometric properties of the underlying graph.

Prerequisites / notice
- Probability Theory.
- Basic properties of Markov Chains.
- No prerequisite on group theory, all the background will be introduced in class.

401-4037-DRL O-Minimality and Diophantine Applications
Only for ZGSM (ETH D-MATH and UZH I-MATH) doctoral students. The latter need to register at myStudies and then send an email to info@zgsm.ch with their name, course number and student ID. Please see https://zgsm.math.uzh.ch/index.php?id=forum0

Abstract
This course is the second of a sequence of two courses on mathematical finance. The first course “Introduction to Mathematical Finance” (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imsf/education/education-in-stochastic-finance/overview-of-courses.html.
At the end of the course students will be able to differentiate between three types of manifolds, give examples showing various
difficulties arise. Moreover, they will become familiar with many open problems that are guiding current research, especially in the peculiar
dimension four.

The overall goal of this course is to provide an introduction to o-minimality and the applications of o-minimal structures.

The first part of the course will be devoted to an introduction to model theory as a framework in which to define o-minimal structures. The
main result will be the "cell decomposition theorem", which describes the shape of definable subsets of an o-minimal structure. In the
second part of the course, we will discuss examples of interesting o-minimal structures, and then consider applications to number theory.

These may include Pila-Wilkie counting theorem, or the Pila-Zannier strategy in the context of the Manin-Mumford conjecture.

This course is appropriate for people with basic knowledge of abstract algebra and commutative algebra. Some knowledge of differential
geometry, mathematical logic or some number theory is welcome, but not required.

This course is for people with basic knowledge of algebraic geometry (scheme theory) and algebraic topology.

The aim of this course is to give an introduction to A¹-homotopy theory following Morel and Voevodsky.

In particular, we will develop

The overall goal of this course is to give an introduction to A¹-homotopy theory following Morel and Voevodsky. In particular, we will develop

the aim of this course is to give an introduction to A¹-homotopy theory following Morel and Voevodsky. In particular, we will develop

the aim of this course is to give an introduction to A¹-homotopy theory following Morel and Voevodsky.
- Microlocal Analysis studies singularities of distributions in phase space, by describing the behaviour of a singularity in both position and direction. It is a part of the field of partial differential equations (PDE), created by Hörmander, Kohn, Nirenberg, and others in the 1960s and 1970s, and is used to study questions such as solvability, regularity, and propagation of singularities of solutions of PDEs. To name a few classical applications: asymptotics of eigenvalues for elliptic operators (Weyl law), trace formulas, and inverse problems.

- There have been recent exciting applications of Microlocal Analysis to Dynamical Systems and Geometry. These range from Dynamical Zeta Functions, Resonances and decay of correlations, to injectivity properties of X-ray (geodesic) transforms, and applications to Rigidity questions in Geometry.

- The goal of this course is to introduce the powerful tools of Microlocal Analysis, and to present some striking applications in Chaotic Dynamical Systems. Here are the details (subject to changes):

  1. Distributions and Fourier Transform (recap), Symbol classes and Oscillatory Integrals. Fourier Integral Operators. Stationary Phase Lemma. (3 lectures)
  2. Pseudodifferential Operators (PDO). Compositions, changes of coordinates, calculus of PDOs. PDOs on manifolds. (2 lectures)
  3. Elliptic regularity. L^2-continuity. Sobolev spaces and PDOs. (2 lectures)
  4. Wavefront set. Products, pullbacks of distributions. (1 lecture)
  5. Applications: 1) construction of anisotropic Sobolev spaces for chaotic dynamics, existence of Pollicott-Ruelle resonances. 2) Ergodicity and Mixing. 3) Possible applications: Ruelle Zeta Function, exponential Mixing for contact Anosov flows, Frame Flows and Parry's representation. (6 lectures)

The lecturer will provide lecture notes tailored to the course.

**Literature**

-S. Dyatlov, M. Zworski, Dynamical zeta function for Anosov flows via microlocal analysis, Annales de l'ENS, 49(2016), 543--577.

**Prerequisites / notice**

Prior Knowledge: Basic Fourier Analysis and basic knowledge of Distribution Theory are desired, but both will be recalled at the start. Familiarity to basic differential geometry and functional analysis, but all objects will be recalled.

**Seminars**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-4600-72L</td>
<td>Student Seminar in Probability</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>J. Bertoin, V. Tassion, W. Werner</td>
</tr>
</tbody>
</table>

Limited number of participants. Registration to the seminar will only be effective once confirmed by email from the organizers.

This Student Seminar in Probability will be at an advanced level (dealing with current research topics), and the participants will be at a doctoral level or postdocs. Of course, non-participants are welcome to attend the various talks of the seminar.

**Colloquia**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>R. Abgrall, M. Iacobelli, R. Bandeira, A. Iozzi, S. Mishra, P. Pandharipande</td>
</tr>
</tbody>
</table>

The Graduate Colloquium is an informal seminar aimed at graduate students and postdocs whose purpose is to provide a forum for communicating one's interests and thoughts in mathematics.

**Notice**

The number of participants to the seminar is limited. Registration to the seminar will only be effective once confirmed by email from the organizers.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 833 of 2416
### Mathematics

**Abstract**

Research colloquium

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>A. Cattaneo, G. Felder, M. Gaberdiel, G. M. Graf, P. Hintz, T. H. Willwacher</td>
</tr>
<tr>
<td>401-5600-00L</td>
<td>Seminar on Stochastic Processes</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>J. Bertoin, A. Nikeghbali, B. D. Schlein, V. Tassion, W. Werner</td>
</tr>
<tr>
<td>401-5680-00L</td>
<td>Foundations of Data Science Seminar</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>P. L. Bühlmann, A. Bandeira, H. Bölcskei, S. van de Geer, F. Yang</td>
</tr>
<tr>
<td>401-5660-00L</td>
<td>DACO Seminar</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>A. Bandeira, R. Weismantel, R. Zenklusen</td>
</tr>
<tr>
<td>401-5910-00L</td>
<td>Talks in Financial and Insurance Mathematics</td>
<td>E-</td>
<td>0</td>
<td>1K</td>
<td>B. Acciaio, P. Cheridito, D. Possamaï, M. Schweizer, J. Teichmann, M. V. Wüthrich</td>
</tr>
<tr>
<td>252-4202-00L</td>
<td>Seminar in Theoretical Computer Science</td>
<td>E-</td>
<td>2</td>
<td>2S</td>
<td>E. Welzl, B. Gärtner, M. Hoffmann, J. Lengler, A. Steger, D. Steurer, B. Sudakov</td>
</tr>
</tbody>
</table>

**Objective**

Presentation of recent publications in theoretical computer science, including results by diploma, masters and doctoral candidates. The goal is to introduce students to current research, and to enable them to read, understand, and present scientific papers. This seminar takes place as part of the joint research seminar of several theory groups. Intended participation is for students with excellent performance only. Formal restriction is: prior successful participation in a master level seminar in theoretical computer science.

### Transferable Skills

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>900-0100-DRL</td>
<td>Transferable Skills Course I (1-3 days)</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

| 900-0101-DRL | Transferable Skills Course II (1-3 days)        | W    | 1    | 2S    | Lecturers |

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

| 900-0102-DRL | Transferable Skills Course III (1-3 days)       | W    | 1    | 2S    | Lecturers |

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

| 900-0103-DRL | Transferable Skills Course I (1-3 days, with Poster or Talk) | W    | 2    | 4S    | Lecturers |

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
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<tr>
<th>Code</th>
<th>Name</th>
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<td>3</td>
<td>Autumn Semester 2022</td>
<td>Lecturers</td>
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**Objective**

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### Objective
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<th>Course Code</th>
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### Course Codes and Descriptions
- **900-0155-DRL**: Summer School III (1-3 days, with Poster or Talk)
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  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
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  - Objective: Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

### External Conference I (incl. Poster or Talk)
- Only for doctoral students.
- Abstract: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- Objective: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

### Courses with Minimum Duration of 4 Days
- **900-0156-DRL**: Summer School I (min 4 days)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in summer or winter schools with a minimum duration of 4 days.
  - Objective: Participation in summer or winter schools with a minimum duration of 4 days.
- **900-0157-DRL**: Summer School II (min 4 days)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in summer or winter schools with a minimum duration of 4 days.
  - Objective: Participation in summer or winter schools with a minimum duration of 4 days.
- **900-0158-DRL**: Summer School III (min 4 days)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in summer or winter schools with a minimum duration of 4 days.
  - Objective: Participation in summer or winter schools with a minimum duration of 4 days.
- **900-0159-DRL**: Summer School I (min 4 days, with Poster or Talk)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
  - Objective: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
- **900-0160-DRL**: Summer School II (min 4 days, with Poster or Talk)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
  - Objective: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
- **900-0161-DRL**: Summer School III (min 4 days, with Poster or Talk)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
  - Objective: Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.
- **900-0162-DRL**: External Conference I (incl. Poster or Talk)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
  - Objective: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
- **900-0163-DRL**: External Conference II (incl. Poster or Talk)
  - Only for doctoral students.
  - Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
  - Abstract: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
  - Objective: Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.
Only for doctoral students.

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**900-0164-DRL External Conference III (incl. Poster or Talk)**

| Only for doctoral students. |

**Abstract**
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

**Objective**
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

900-0164-DRL External Conference III (incl. Poster or Talk) **W** 1 credit **2K Lecturers**

**Doctorate Mathematics - Key for Type**

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<th>W+</th>
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<td>Recommended, not eligible for credits</td>
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<td>W</td>
<td>Recommended, not eligible for credits</td>
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<td>O</td>
<td>Compulsory</td>
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**Key for Hours**

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<tr>
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<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>seminar</td>
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<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Subject Specialisation

Please note that this is an INCOMPLETE list of courses.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<td>Semiconductor Materials: Fundamentals and Fabrication</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>S. Schön, W. Wegscheider</td>
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</tbody>
</table>

**Abstract**

This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

**Objective**

Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

**Content**

1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

**Lecture notes**

https://moodle-app2.let.ethz.ch/course/view.php?id=

**Prerequisites / notice**

The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

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<td>Black Holes and Gravitational Waves</td>
<td>W</td>
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<td>4G</td>
<td>L. Heisenberg, F. D'Ambrosio, A. Giusti</td>
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**Abstract**

The course will discuss some hot topics in gravitational physics, providing an overview on the necessary formalism and its applications to black hole physics and gravitational waves.

**Objective**

The course aims at providing a general introduction to the necessary tools needed to approach two very active research topics in gravitational physics: 1) theoretical black hole physics; 2) gravitational waves. Time permitting, more formal concepts like the initial value problem in general relativity and quasi-local notions of horizon will be discussed. The course will include a brief introduction to general relativity and differential geometry.

**Contents:**

1. Brief introduction to Differential Geometry and General Relativity;
2. Elementary black hole solutions in general relativity and their properties;
3. Conserved charges;
4. Geometry of hypersurfaces and horizons;
5. Singularity theorems;
6. Hawking radiation and the information loss paradox;
7. Generalities on gravitational waves;
8. Phenomenology of black hole mergers

**Lecture notes**

Lecture notes and/or slides will be made available prior to each lecture.

**Literature**

N. Straumann, General Relativity, (Springer, 2013)
P. Jetzer, Applications of General Relativity, (Springer, 2022)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0442-00L</td>
<td>Quantum Optics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>A. Imamoglu</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

**Objective**

The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

**Content**

This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:

- coherence properties of light
- quantum nature of light: statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

**Lecture notes**

Selected book chapters will be distributed.
Text-books:

- G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Optics
- R. Loudon, The Quantum Theory of Light
- Atomic Physics, Christopher J. Foot
- Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
- C. Cohen-Tannoudji et al., Atom-Photon-Interactions
- M. Scully and M.S. Zubairy, Quantum Optics
- Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

**402-0442-05L Advanced Topics in Quantum Optics**

<table>
<thead>
<tr>
<th>Number of participants limited to 25.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong> The lecture will cover current topics and scientific papers in the wider field of quantum optics in an interactive format. First, the research area will be introduced, then several papers of this field will be presented by the students in the style of a journal club. Selected papers will be contrasted and their strengths and weaknesses discussed by the students in panel discussions. Furthermore, r</td>
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<tr>
<td><strong>Objective</strong> The aim of the lecture is to deepen and broaden the knowledge about current research in the field of quantum optics. In addition, it will also be discussed and critically examined how research results are communicated via publications and lectures and which techniques are used in the process.</td>
</tr>
<tr>
<td><strong>Content</strong> We will select topical fields in quantum optics and quantum science and discuss recently published work.</td>
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</table>

- Topics:
  - Atoms or ions-based quantum computing
  - Quantum simulation
  - Opto-mechanics
  - Driven and dissipative quantum systems
  - Cavity based atom-light interaction
  - Topological photonics

The interactive part of the lecture will include presentations of recent papers, panel discussions of recent papers and the writing of a critical assessment of an arXiv paper in the style of a referee report.

**402-0457-00L Quantum Technologies for Searches of New Physics**

<table>
<thead>
<tr>
<th>W 6 credits 2V+1U P. Crivelli, D. Kienzler</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong> Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.</td>
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<td><strong>Objective</strong> The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.</td>
</tr>
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</table>
| **Content** The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.
  - Cold atoms
  - Trapped ions
  - Atoms interferometry
  - Atomic clocks
  - Cold molecules and molecular clocks
  - Exotic Atoms
  - Anti-matter
  - Quantum Sensors

The main lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces. |

**402-0484-00L Experimental and Theoretical Aspects of Quantum Gases**

<table>
<thead>
<tr>
<th>W 6 credits 2V+1U T. Esslinger</th>
</tr>
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<tbody>
<tr>
<td><strong>Abstract</strong> Quantum Gases are the most precisely controlled many-body systems in physics. This provides a unique interface between theory and experiment, which allows addressing fundamental concepts and long-standing questions. This course lays the foundation for the understanding of current research in this vibrant field.</td>
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<td><strong>Content</strong> Cooling and trapping of neutral atoms Bose and Fermi gases Ultraceold collisions The Bose-condensed state Elementary excitations Vortices Superfluidity Interference and Correlations Optical lattices</td>
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</table>

**402-0465-58L Intersubband Optoelectronics**

<table>
<thead>
<tr>
<th>W 6 credits 2V+1U G. Scalari</th>
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Mostly the original articles, other useful reading can be found in:

After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview of the rich physics of the optical properties of semiconductors, as well as the advanced processing available on these material, enabled by the rapidly growing range of applications (lasers, LEDs and solar cells) as well as the realization of new physical concepts. Systems that will be covered include quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

The lecture will treat the following chapters:
- Introduction: intersubband optoelectronics as an example of quantum engineering
- Technological aspects
- Electronic states in semiconductor quantum wells
- Intersubband absorption and scattering processes
- Mid-IR and THz ISB Detectors
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
  - Mid-IR QCLs
  - THz QCLs (direct and non-linear generation)
- Further electronic confinement: interlevel Qdot transitions and magnetic field effects
- Strong light-matter coupling in Mid-IR and THz range

Lecture notes
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum electronics.

Preliminary contents for the HS21:
- Quantum mechanics or to attend effectively more advanced courses on this topic.

At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Preliminary contents for the HS21:
- Atomic paramagnetism and diamagnetism, itinerant and local-moment interatomic coupling, magnetic order at finite temperature, spin precession, approach to equilibrium through thermal and quantum dynamics, dipolar interaction in solids
- Identify the mechanisms from which exchange interaction originates in solids (itinerant and local-moment magnetism)
- Evaluate the consequences of the interplay between competing interactions and thermal energy
- Discriminate the dynamic responses of a magnet to different external stimuli

The lecture can also be followed by interested non-physics students as basic concepts will be introduced.

Requirements: A basic knowledge of solid-state physics and of quantum electronics.

Lecture notes
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

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Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum electronics.
Learning material will be made available through a dedicated RStudioServer and through Moodle.

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

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</tbody>
</table>

### 402-0468-15L Nanomaterials for Photonics

<table>
<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>R. Grange</th>
</tr>
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<tbody>
<tr>
<td>Abstract</td>
<td>The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Content | 1. Introduction to nanomaterials for photonics  
a. Classification of nanomaterials  
b. Light-matter interaction at the nanoscale  
c. Examples of nanophotonic devices  
2. Wave physics for nanophotonics  
a. Wavelength, wave equation, wave propagation  
b. Dispersion relation  
c. Interference  
d. Scattering and absorption  
e. Coherent and incoherent light  
3. Analogies between photons and electrons  
a. Quantum wave description  
b. How to confine photons and electrons  
c. Tunneling effects  
4. Characterization of Nanomaterials  
a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED  
b. Light scattering techniques: DLS  
c. Near field microscopy: SNOM  
d. Electron microscopy: SEM, TEM  
e. Scanning probe microscopy: STM, AFM  
f. X-ray diffraction: XRD, EDS  
5. Fabrication of nanomaterials  
a. Top-down approach  
b. Bottom-up approach  
6. Plasmonics  
a. What is a plasmon, Drude model  
b. Surface plasmon and localized surface plasmon (sphere, rod, shell)  
c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering  
d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication  
e. Applications  
7. Organic and inorganic nanomaterials  
b. Carbon nanotubes: properties, bandgap description, fabrication  
c. Graphene: motivation, fabrication, devices  
d. Nanomarkers for biophotonics  
8. Semiconductors  
a. Crystalline structure, wave function  
b. Quantum well: energy levels equation, confinement  
c. Quantum wires, quantum dots  
d. Optical properties related to quantum confinement  
e. Example of effects: absorption, photoluminescence  
f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade  
9. Photonic crystals  
a. Analogy photonic and electronic crystal, in nature  
b. 1D, 2D, 3D photonic crystal  
c. Theoretical modelling: frequency and time domain technique  
d. Features: band gap, local enhancement, superprism...  
10. Nanocomposites  
a. Effective medium regime  
b. Metamaterials  
c. Multiple scattering regime  
d. Complex media: structural colour, random lasers, nonlinear disorder

### 402-0595-00L Semiconductor Nanostructures

<table>
<thead>
<tr>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>T. M. Ihn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>References will be given during the lecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Basics of solid-state physics (i.e. energy bands) can help</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Slides and book chapter will be available for downloading</td>
<td></td>
<td></td>
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<tr>
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</tbody>
</table>
1. Introduction and overview
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

- The integer quantum Hall effect
- Conductance quantization in quantum point contacts
- The Aharonov-Bohm effect
- Coulomb blockade in quantum dots

2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Lecture notes

Literature
In addition to the lecture notes, the following supplementary books can be recommended:

7. Golub, Richardson & Lamoreaux: "Ultra-Cold Neutrons"
8. Rauch & Werner: "Neutron Interferometry"
9. Carlile & Willis: "Experimental Neutron Scattering"
10. Byrne: "Neutrons, Nuclei and Matter"
11. Klapdor-Kleingrothaus: "Non Accelerator Particle Physics"
12. Byrne: "Neutrons, Nuclei and Matter"
13. Carlile & Willis: "Experimental Neutron Scattering"
14. Klapdor-Kleingrothaus: "Non Accelerator Particle Physics"

Prerequisites / notice
The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.
<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Lectures</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0767-00L</td>
<td>Neutrino Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>A. Rubbia, D. Sgalaberna</td>
</tr>
</tbody>
</table>

**Abstract**

Theoretical basis and selected experiments to determine the properties of neutrinos and their interactions (mass, spin, helicity, chirality, oscillations, interactions with leptons and quarks).

**Objective**

Introduction to the physics of neutrinos with special consideration of phenomena connected with neutrino masses.

**Lecture notes**


<table>
<thead>
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<tbody>
<tr>
<td>D.O. Caldwell, Current Aspects of Neutrino Physics, Springer.</td>
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<tr>
<td>402-0831-67L</td>
<td>Advanced Topics of General Relativity and Gravitational Waves (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Jetzer</td>
</tr>
</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

**UZH Module Code:** PHY529

**Abstract**

The aim of this lecture is to discuss some advanced topics in general relativity, which are useful to understand the present research activities in the field. A list of possible topics is given below. A basic knowledge of general relativity is required (ideally having followed the lecture on General Relativity). The course is particularly suited for master and PhD students.

**Objective**

Is to be able to read and understand the original literature and the presently published papers in the field of the discussed advanced topics. This might also be useful in doing afterwards a master thesis in the field of general relativity.

**Content**

- General relativistic stellar structure equations (Neutron stars)
- Tetrad formalism
- Spinors in GR
- Klein-Gordon & Dirac eqs. in GR
- Thermodynamics of black holes and Hawking radiation
- Topics in gravitational waves: GW generation by PN sources, GW from elliptic, hyperbolic binaries
- Tests of the equivalence principle

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<tr>
<td>402-0845-61L</td>
<td>Effective Field Theories for Particle Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Stoffer</td>
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</table>

**Abstract**

The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. These topics will be discussed both in general terms and with specific phenomenological applications in the context of physics beyond the Standard Model, effective description of the weak interaction, and as the description of non-perturbative strong interaction at low energies.

**Objective**

This course covers the basic concepts of effective field theories (EFTs) and dispersion theory. We will start by introducing the core concept of constructing EFTs and apply them to the low-energy description of the weak interaction and the effective description of heavy physics beyond the Standard Model.

In the next part of the course, we will discuss Chiral Perturbation Theory (ChPT), the low-energy effective theory of Quantum Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

**Content**

- Introduction to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

**Prerequisites / notice**

QFT-I (mandatory) and QFT-II (highly recommended)

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<tr>
<td>402-0845-80L</td>
<td>Scattering Amplitudes</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>V. Del Duca</td>
</tr>
</tbody>
</table>

**Abstract**

This course provides a pedagogical introduction to an advanced topic in Quantum Field Theories, which has undergone a tremendous progress in the new millennium: scattering amplitudes and on-shell methods.

**Objective**

Students that complete the course will be able to understand the basics of the modern methods to compute scattering amplitudes, to perform simple calculations and to read modern publications on this research field.
This course covers the basic concepts of:

- spinor helicity formalism
- colour decompositions
- on-shell recursion relations
- colour-kinematics duality
- scattering equations
- unitarity:
  - optical theorem
  - uniqueness of Yang-Mills
  - uniqueness of General Relativity
  - unitarity method
- Feynman integrals. IBPs and differential equations
- analytic and algebraic structure of loop-level amplitudes:
  - Hopf algebra, symbols and coproducts
  - multiple polylogarithms (a.k.a. as iterated integrals on the Riemann sphere)
  - elliptic and modular-form integrals (a.k.a. as iterated integrals on the torus)

Lecture notes
Will be provided at the Moodle site for the course.

Literature
Will be provided at the Moodle site for the course.

Prerequisites / notice
A basic knowledge of Feynman rules in scalar field theories and in Yang-Mills theory is assumed.

QFT-I, QFT-II and Introduction to Quantum ChromoDynamics are highly recommended.

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Abstract
This year we celebrate the tenth anniversary of the discovery of the Higgs boson. With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background and learn how to implement the main experimental methods used to study the physics of the Higgs boson.

Objective
With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background to understand the main production and decay channels of the Higgs boson at high-energy colliders, and the corresponding experimental signatures.

Content
Theory part:
- the Standard Model and the mass problem: WW scattering and the no-lose theorem
- the Higgs mechanism and its implementation in the Standard Model
- radiative corrections and the screening theorem
- theoretical constraints on the Higgs mass; the hierarchy problem
- Higgs production in e+e- collisions
- Higgs production at hadron colliders
- Higgs decays to fermions and vector bosons
- Higgs differential distributions, rapidity distribution, pt spectrum and jet vetoes
- Higgs properties and beyond the Standard Model perspective

Outlook: The Higgs sector in weakly coupled and strongly coupled new physics scenarios.

Experimental part:
Introductory material:
- basics of accelerators and detectors
- reminders of statistics: likelihoods, hypothesis testing
- reminders of multivariate techniques: Boosted Decision Trees and Neural Networks

Main topics:
- pre-history (pre-LEP)
- LEP1: measurements at the Z-pole
- Electroweak constraints
- LEP2: towards the limit mH<114 GeV
- TeVatron searches
- LHC
- main channels overview
- dissect one analysis
- combine information from all channels
- differential measurements
- off-shell measurements

Literature
- Higgs Hunter's Guide (by S.Dawson, J. Gunion, H. Haber and G. Kane)
- "Combination of Tevatron searches for the standard model Higgs boson in the W-W decay mode" HWW TeVatron combination - http://arxiv.org/abs/1001.4162
- "Evidence for a particle produced in association with weak bosons and decaying to a bottom-antibottom quark pair in Higgs boson searches at the TeVatron" http://arxiv.org/abs/1207.6436
- PDG review of "Leptons in physics at the Tevatron" http://arxiv.org/abs/1412.8662
- "Measurements of the Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data at √s=7 and 8 TeV" https://arxiv.org/abs/1606.02266
- "Projections of Higgs Boson measurements with 30 fb at 8 TeV and 300 fb at 14 TeV" https://twiki.cern.ch/twiki/bin/view/CMSPublic/HiggsAnalysisCmsRun2/TTWiki

Prerequisites / notice
- Quantum Field Theory I
- Phenomenology of Particle Physics I
- does not take place this semester.
Abstract

String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Objective

Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Content

- mechanics of point particles and extended objects
- string modes and their quantisation; higher dimensions, supersymmetry
- D-branes, T-duality
- supergravity as a low-energy effective theory, strings on curved backgrounds
- two-dimensional field theories (classical/quantum, conformal/non-conformal)

Literature

M.B. Green, J.H. Schwarz, E. Witten, Superstring Theory I, CUP (1987).

Prerequisites / notice

Recommended: Quantum Field Theory I (in parallel)

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Enrollment is only possible under
https://www.lehrbetrieb.ethz.ch/laborpraktika
No registration required via myStudies.

Abstract

Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists.

Objective

The "IT at D-PHYS" introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.

The "IT and Information Security" crash course will address the most common threats you'll encounter when using the internet and teach you how to fend them off.

The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges.

Objective

The "Linux Basics" modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization.

The "Python Ecosystem" modules present various aspects on the ecosystem around Python, without covering the programming language itself. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing code. From development environments (IDE, Jupyter), over code formatters and linters, to skimming selected concepts (string formatting, regular expressions).

The "System Aspects module" deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it.

Use the dedicated web page https://www.lehrbetrieb.ethz.ch/laborpraktika to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to https://compenv.phys.ethz.ch for the detailed contents.

Content

Introduction:

IT at D-PHYS (IT service providers and IT services at D-PHYS)
IT and Information Security

Modules:

Linux Basics I (system components, basic shell usage)
Linux Basics II (advanced tools, scripting)
Python Ecosystem I (interpreters, packages, virtual environments)
Python Ecosystem II (development environments, formatter and linter, string formatting, regexp)
System Aspects (how the hardware affects your scientific code and vice versa)

Objective

The seminar is aimed at all students who, during their studies, are confronted with age determination methods based on long-living radionuclides found in nature. Basic methodology, the latest developments, and special examples from a wide range of applications will be discussed.

Objective

The seminar provides the participants an overview about newest trends and developments of accelerator mass spectrometry (AMS) and related applications. In their talks and subsequent discussions the participants learn intensively about the newest trends in the field of AMS thus attaining a broad knowledge on both, the physical principles and the applications of AMS, which goes far beyond the horizon of their own studies.

Objective

The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.

Objective

The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.
## Transferable Skills

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Prerequisites / notice

For doctoral students of the Neuroscience Center Zurich (ZNZ).
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</table>
Member of Executive Board (min 1 year)  

Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Active participation in the presidium or executive board of a university group for at least 1 year.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Ethics and Scientific Integrity for Doctoral Students in Physics

Abstract
This course sensitises doctoral students to ethical issues that may occur during their doctoralate. After an introduction to ethics and good scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students get the chance to apply their knowledge in a context specific to research in physics.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. In addition, they will reflect on their professional role as scientific researchers.

Content
Part I on Moodle

The self-paced e-learning course on Moodle consists of 5 modules:

Module 1: Ethics
- Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
- Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
- A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
- Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
- Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices, or solve ethical dilemmas. But also where to seek advice if needed).

Part II
The second, face-to-face part of this course focuses on physics-specific aspects. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students of D-PHYS only.

The first part on Moodle (part I) must be successfully completed before the face-to-face workshop (part II).

Hence, when you choose a group make sure you have enough time to finish the first part on Moodle before the workshop starts (appr. 20 hours).

Learning to Teach

This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities.

Abstract
This course imparts a variety of teaching skills which will help Doctoral Teaching Assistants with their teaching tasks.

In this course Doctoral Teaching Assistants will ...
• discuss learning science and teaching techniques with peers.
• design the introduction of their course/lecture/exercise class.
• develop learning activities according to learning objectives.
• practice classroom assessment techniques in order to measure student learning.
• engage in peer feedback in order to improve own teaching.

Objective
In this course Doctoral Teaching Assistants will ...

Content
We will meet for the kick-off meeting online on the 3rd of October 2022 from 1-3 pm. You will get detailed information together with the invitation email in the first week of the semester. The online phase, where you work through 6 modules in the Moodle course page will end by the 11th of November 2022. We will meet on the 16 or 17th of November 22 for the Consolidation workshop. You will find more information on the course page in Moodle.

Prerequisites / notice
This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities (exercises, excursions, supervision of practicals, lectures, etc.) or those who will assume teaching tasks in the semester following the programme. No previous teacher training is required.

Language Courses ETH/UZH: see Science in Perspective
Educational Science for Teaching Diploma and TC
D-GESS: Science in Perspective

Integration into Scientific Community

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</table>

900-0151-DRL | Summer School II (1-3 days)                      | W    | 1    | 2K    | Lecturers |
<p>|            | Only for doctoral students.                      |      |      |       |           |</p>
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credit</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>900-0152-DRL</td>
<td>Summer School III (1-3 days)</td>
<td>1</td>
<td>2K</td>
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<tr>
<td>900-0153-DRL</td>
<td>Summer School I (1-3 days, with Poster or Talk)</td>
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<td>900-0156-DRL</td>
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<tr>
<td>900-0158-DRL</td>
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<td>4K</td>
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<tr>
<td>900-0159-DRL</td>
<td>Summer School I (min 4 days, with Poster or Talk)</td>
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<td>900-0160-DRL</td>
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<td>6K</td>
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Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0161-DRL Summer School III (min 4 days, with Poster or Talk) W 3 credits 6K Lecturers

Abstract Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0162-DRL External Conference I (incl. Poster or Talk) W 1 credit 2K Lecturers

Abstract Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0163-DRL External Conference II (incl. Poster or Talk) W 1 credit 2K Lecturers

Abstract Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

900-0164-DRL External Conference III (incl. Poster or Talk) W 1 credit 2K Lecturers

Abstract Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective Participation in summer or winter schools with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

Doctorate Physics - Key for Type

W+ Eligible for credits and recommended
W Eligible for credits
E- Recommended, not eligible for credits
Z Courses outside the curriculum
Dr Suitable for doctorate
O Compulsory

Key for Hours

V lecture
G lecture with exercise
U exercise
S seminar
K colloquium
P practical/laboratory course
A independent project
D diploma thesis
R revision course / private study

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Subject Specialisation

Agricultural Sciences

Graduate Programme in Plant Sciences

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>751-4003-01L</td>
<td>Current Topics in Grassland Sciences (HS)</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>N. Buchmann</td>
</tr>
</tbody>
</table>

Abstract
Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

Objective
Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.

Content
Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.

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<tbody>
<tr>
<td>551-0205-00L</td>
<td>Challenges in Plant Sciences</td>
<td>W</td>
<td>2</td>
<td>2K</td>
<td>S. C. Zeeman, S. Mintchev, M. Paschke, B. Pfister, further lecturers</td>
</tr>
</tbody>
</table>

Abstract
The colloquium “Challenges in Plant Sciences” is a core class of the Zurich-Basel Plant Science Center’s PhD program and the MSc module. The colloquium introduces participants to the broad spectrum of plant sciences within the network. The course offers the opportunity to approach interdisciplinary topics in the field of plant sciences.

Objective
Objectives of the colloquium are:
- Introduction to recent research in all fields of plant sciences
- Working in interdisciplinary teams on the topics
- Developing presentation and discussion skills

Content
The topics encompass integrated knowledge on current plant research, ranging from the molecular level to the ecosystem level, and from basic to applied science while making use of the synergies between the different research groups within the PSC.

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<tr>
<td>551-0209-00L</td>
<td>Sustainable Plant Systems (Seminar)</td>
<td>Dr</td>
<td>2</td>
<td>2S</td>
<td>M. Paschke, S. F. Bender, G. S. Bhullar, F. Liebisch, further lecturers</td>
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</table>

Abstract
Participants will be able to discuss and understand sustainability in the context of plant science research. A special focus will be on research on agro-ecological systems and farming system research.

Objective
Participants will be able to:
1. Review issues of sustainability in the context of plant science research and literature on sustainable agriculture and the food system.
2. Analyze and interact on several case studies in agro-ecology and the food system.
3. Use SDGs in your case study as a target and assessment system for sustainability in agriculture and in the food system.
Content

Future society has to feed nine billion people, therefore agriculture but also food, waste and resource management has to go hand in hand in the use of less resources. We will discuss current plant science research in the context of sustainability.

Focus of the seminar will be on:
(1) Research on agro-ecological systems and farming system research. Can we transform the impact of our agricultural practices below the planetary boundaries? Where does current research indicate on directions for a transformation of current practice?
(2) The Sustainable Development Goals that should guide the current contributions of plant sciences: What research and innovation are necessary to contribute to the SDGs?
(3) Building sustainable food systems: How could local food systems be build and scaled up? In this topic, our focus is on giving insight in policy strategies and local sustainability efforts to give the group of participants an opportunity to understand sustainability in the local societal context.

The course will be organized with two workshops (half days, 14:00 - 18:00) and an intensive, well-structured self-study/ group work phase in between the workshops.

Online learning material is for example provided on:

- Nitrogen supply in tropical low input conservation agriculture
- Nitrous oxide emissions from agriculture
- Role of vascular plants in methane emissions from soil
- Mycorrhizal symbioses for soil nutrient management in agro-ecosystems

Case Studies:
- How do you farm sustainably?
- What influence do the consumers in developed (importing) countries have on sustainability of (mainly) small-holder farming in the developing (sourcing) countries?
- How can Swiss farmers move to zero environmental impact?
- Sensor based fertilization techniques for sustainability?

The sustainable development goals (SDG) and sustainable urban food systems.

Lecture notes

Access to the learning platform: https://lms.uzh.ch/auth/RepositoryEntry/3604873218/CourseNode/83441794245107 (use your AAI login)

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Problem-solving

Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Self-presentation and Social Influence
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Social Competencies
- Communication
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

751-1050-00L Compositional data analysis (CODA) W 1 credit 2G M. Templ

Participants of PhD Program in Plant Sciences have priority - open to other PhD students if places are available.

Please register additionally to the registration in ETHZ course catalogue here: https://ethz.ch/staffnet/en/service/courses-continuing-education.html (select Plant Sciences)

Abstract

Compositional data analysis is a methodology used to describe the parts/compounds of a whole, conveying relative information.

Typical examples in different fields are: geology (geochemical elements), medicine (body composition: fat, bone, lean), food industry (food composition: fat, sugar, etc), chemistry (chemical composition), ecology (abundance of different species), agriculture (nutrient balance in plants), biology (DNA/RNA content in a cell).

Objective

Students will be able to:
- decide where (and where not) methods for analyzing compositional data can be used
- describe what their properties are and what challenges are associated with them, and to decide which method to choose for their research task
- critically evaluate the model results of a compositional data approach in the context of plant science.

Content

The objective of this course is to introduce students with a basic programming background to compositional data analysis. We will discuss topics like the geometric properties of compositional data in plant science including the representation of data in so-called log-ratio coordinates, explanatory data analysis and visualization, location and covariance measures, application to multivariate analysis (e.g. cluster analysis), linear models and we give an outline on problems for high-dimensional data. In addition, problems with missing values, zeros and outliers are discussed. The course will consist of 50% lectures and 30% hands-on programming in R, where students will directly apply methods in software to help solving problems in plant sciences, and 20% is spent on a given task.

Literature


Prerequisites / notice

Participants should bring their laptops to the exercises with the R software environment and a suitable editor (e.g. RStudio) installed. It is assumed that students enrolling in this course have successfully completed a fundamentals of data science or statistics course and are familiar with programming (preferably in R).

Participants of PhD Program in Plant Sciences have priority.


701-1425-01L Genetic Diversity: Techniques W 2 credits 4P A. M. Minder Pfyl

Number of participants limited to 8.

Waiting list will be deleted 08.11.22.
No enrollment possible after 31.10.22.

Abstract

This course provides laboratory training for advanced students (master, doctoral or post-doctoral level). Different DNA/RNA extraction protocols, quality control measurements, SNP genotyping and gene expression techniques will be addressed. This is a course for practitioners.
Objective
To learn and improve on standard and modern methods of genetic data collection. With a focus on: Use of different extractions protocols, techniques for quality control measurements, gene expression, pyrosequencing and other SNP genotyping techniques.

Content
After an introduction (one afternoon), students have 3 weeks to work independently in groups of two on different protocols. At the end of this practical part, the whole class meets for another afternoon to present the techniques/results and to discuss the advantages and disadvantages of the different techniques.
Techniques addressed are: RNA/DNA extractions and quality control, SNP genotyping, pyrosequencing, real-time qPCR.

Lecture notes
Material will be handed out in the course.

Literature
Material will be handed out in the course.

Prerequisites / notice
Two afternoons are held in the class. The lab work will be done from the students according to their timetable, but has to be finished after 3 weeks. Effort is roughly 1-2 full days per week, depending on the skills of the student.

Environmental Sciences

Atmosphere and Climate

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<tbody>
<tr>
<td>701-1239-00L</td>
<td>Aerosols I: Physical and Chemical Principles</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>M. Gysel Beer, D. Bell, E. Weingartner</td>
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</tbody>
</table>

Abstract
Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

Objective
Physical and chemical principles:
The students...
- know the processes and physical laws of aerosol dynamics.
- understand the thermodynamics of phase equilibria and chemical equilibria.
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:
The students...
- know the most important chemical and physical measurement instruments.
- understand the underlying chemistry and physics.

Environmental impacts:
The students...
- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- know the most important climate impacts of atmospheric aerosols.
are aware of the health impacts of atmospheric aerosols.

Lecture notes
Material is distributed during the lecture

Literature

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking not assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

701-1253-00L
Analysis of Climate and Weather Data
W    3    credits  2G    C. Frei

Abstract
An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.

Objective
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.
### Content
The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

### Literature
For complementary reading:

### Prerequisites / notice
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

### 701-1235-00L Cloud Microphysics
**Number of participants limited to 20.**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
<th>Z. A. Kanji, N. Shardt, Y. Wang</th>
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</table>

**Priority is given to PhD students majoring in Atmospheric and Climate Sciences, and remaining open spaces will be offered to the following groups:***
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

All participants will be on the waiting list at first. Enrollment is possible until 14.09.2022. All students will be informed on 15./16.09.2022, if they can participate in the lecture. The waiting list is active until 30.09.2022.

### Abstract
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

### Objective
The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.


### Literature
**Lamb and Verlinde: PHYSICS AND CHEMISTRY OF CLOUDS, Cambridge University Press, 2011**

**Target group: Doctoral and Master students in Atmosphere and Climate**

### Prerequisites / notice
**Subject-specific Competencies**
- Concepts and Theories
- Analytical Competencies
- Problem-solving

**Method-specific Competencies**
- Communication
- Critical Thinking
- Self-direction and Self-management

### Fostered competencies
- Social Competencies
- Personal Competencies
- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies
- Subject-specific Competencies
- Method-specific Competencies
- Social Competencies
- Personal Competencies

### 701-1221-00L Dynamics of Large-Scale Atmospheric Flow
**Number of participants limited to 36.**

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
<th>H. Wernli, L. Papritz</th>
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</thead>
</table>

**The lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostropic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.**

### Abstract
Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

### Objective
**Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.**

### Lecture notes
**Dynamics of large-scale atmospheric flow**
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

### Literature
**Physics I, II, Environmental Fluid Dynamics**

### Prerequisites / notice
**Physics I, II, Environmental Fluid Dynamics**
The course introduces the scientific concepts and typical applications of tracers in biogeochemistry. The course covers stable and radioactive isotopes, geochemical tracers and biomarkers and their application in biogeochemical processes as well as regional and global cycles. The course provides essential theoretical background for the lab course "Isotopic and Organic Tracers Laboratory".

The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and decay modes of relevant radiogenic isotopes. They discover the spectrum of possible geochemical tracers and biomarkers, their potential and limitations and get familiar with important applications.

The students will understand the most important aspects of stratospheric dynamics and the greenhouse gas effect in troposphere and stratosphere. The students will also acquire a good understanding of the coupling between stratospheric ozone and climate change.

Furthermore, they will practice to explain fundamental concepts in stratospheric chemistry by means of scientific paper presentations.

In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

The students will also acquire a good understanding of the role of land processes and associated feedbacks in the climate system.

The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

The students are provided in the contact hours.


701-1233-00L Stratospheric Chemistry W 4 credits 2V+1U T. Peter, G. Chiodo

Abstract

The lecture gives an overview on the manifold reactions which occur in the gas phase, in stratospheric aerosol droplets and in polar cloud particles. The focus is on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.

Objective

The students will understand the gas phase reactions in the stratosphere as well as reactions and processes in aerosol droplets and polar stratospheric clouds.

Furthermore, they will practice to explain fundamental concepts in stratospheric chemistry by means of scientific paper presentations.

701-1211-01L Master's Seminar: Atmosphere and Climate 1 ■ W 3 credits 2S H. Joos, R. Knutti, A. Merrifield Könz, M. A. Wüest

Abstract

In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Objective

Training scientific writing skills.

Content

In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

651-4095-01L Colloquium Atmosphere and Climate 1 W 1 credit 1K H. Joos, H. Wernli, D. N. Bresch, D. Domeisen, N. Gruber, R. Knutti, U. Lohmann, T. Peter, C. Schön, S. Seneviratne, M. Wild

Abstract

The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

Objective

The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

Number Title Type ECTS Hours Lecturers
701-1313-00L Isotopes and Biomarkers in Biogeochemistry W 3 credits 2G C. Schubert, N. Casacuberta Anola, R. Kipter

Abstract

The course introduces the scientific concepts and typical applications of tracers in biogeochemistry. The course covers stable and radioactive isotopes, geochemical tracers and biomarkers and their application in biogeochemical processes as well as regional and global cycles. The course provides essential theoretical background for the lab course “Isotopic and Organic Tracers Laboratory”.

Objective

The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and decay modes of relevant radiogenic isotopes. They discover the spectrum of possible geochemical tracers and biomarkers, their potential and limitations and get familiar with important applications.

Content

Geogenic and cosmogenic radionucleides (sources, decay chains); stable isotopes in biogeochemistry (natural abundance, fractionation); geochemical tracers for processes such as erosion, productivity, redox fronts; biomarkers for specific microbial processes.

Lecture notes

Handouts will be provided for every chapter.

Literature

A list of relevant books and papers will be provided.

Prerequisites / notice

Students should have a basic knowledge of biogeochemical processes (BSc course on Biogeochemical processes in aquatic systems or equivalent).
The students are familiar with the chemical characteristics, the environmental behavior and fate, and the biogeochemical reactivity of important trace elements in aquatic and terrestrial environments and the coupling of abiotic and biotic transformation processes of trace elements. Examples of the role of trace elements in natural or engineered systems will be presented and discussed in the course.

Objective

The students are familiar with the chemical characteristics, the environmental behavior and fate, and the biogeochemical reactivity of different groups of trace elements. They are able to apply their knowledge on the interaction of trace elements with geosphere components and on abiotic and biotic transformation processes of trace elements in aquatic and terrestrial systems.

Content

(i) Definition, importance and biogeochemical classification of trace elements. (ii) Key biogeochemical processes controlling the cycling of different trace elements (base metals, redox-sensitive and chalcophile elements, volatile trace elements) in natural and engineered environments. (iii) Abiotic and biotic processes that determine the environmental fate and impact of selected trace elements.

Lecture notes

Selected handouts (lecture notes, literature, exercises) will be distributed during the course.

Prerequisites / notice

Students are expected to be familiar with the basic concepts of aquatic and soil chemistry covered in the respective classes at the bachelor level (soil mineralogy, soil organic matter, acid-base and redox reactions, complexation and sorption reactions, precipitation/dissolution reactions, thermodynamics, kinetics, carbonate buffer system).

The lecture 701-1315-00L Biogeochemistry of Trace Elements is a prerequisite for attending the laboratory course 701-1331-00L Trace Elements Laboratory, or students must be concurrently enrolled in 701-1315-00L Biogeochemistry of Trace Elements in the same semester.

701-1346-00L Carbon Mitigation

Number of participants limited to 100

Priority is given to the target groups: Bachelor and Master Environmental Sciences and PhD Environmental Sciences until 20.09.2022. Waiting list will be deleted 30.09.2022.

Abstract

Future climate change can only kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

Objective

The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

Content

From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Lecture notes

None

Literature

Will be identified based on the chosen topic.

Prerequisites / notice

Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

860-0012-00L Cooperation and Conflict Over International Water Resources

Number of participants limited to 40.

Priority for Science, Technology, and Policy MSc.

Abstract

This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Objective

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

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<thead>
<tr>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>20.Sep</td>
<td>Global water challenges</td>
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<tr>
<td>27.Sep</td>
<td>Nuts and bolts of hydrological modeling and what such models can tell us</td>
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<tr>
<td>04.Oct</td>
<td>Nuts and bolts of hydrological modeling and what such models can tell us</td>
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<tr>
<td>11.Oct</td>
<td>Water pollution and its mitigation</td>
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<td>18.Oct</td>
<td>Key challenges in international river systems</td>
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<td>25.Oct</td>
<td>Key challenges in international river systems</td>
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<td>01.Nov</td>
<td>Case study 1: Yarmuk</td>
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<td>08.Nov</td>
<td>Case study 2: Mekong</td>
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<td>15.Nov</td>
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<td>29.Nov</td>
<td>Case study 5: Central Asia</td>
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<td>06.Dec</td>
<td>Wrap up: what we can learn from these case studies</td>
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<tr>
<td>13.Dec</td>
<td>Exam</td>
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<td>20.Dec</td>
<td>No class</td>
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</table>

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Lecture notes

Slides and reading materials will be made available via Moodle.

Literature

Slides and reading materials will be made available via Moodle.

Prerequisites / notice

The course is open to Master and doctoral students from any area of ETH. Limited to 40 students.

Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.
This five-day winter school aims at teaching advanced Master students, PhD students and postdoctoral researchers on aspects of the Genomics of Environmental Adaptation.

After an introduction (one afternoon), students have 3 weeks to work independently in groups of two on different protocols. At the end of this practical part, the whole class meets for another afternoon to present the techniques/results and to discuss the advantages and disadvantages of the different techniques.

Students will be able to: 1) critically consider biological data books and local, regional, and national inventories; 2) evaluate the validity of ecological criteria used in decision making processes; 3) critically appraise the handling of ecological data and criteria used in the process of evaluation 4) perform an ecological evaluation project from the field survey up to the decision making and planning.

The course structure between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Waiting list will be deleted 19.01.2023.

Prerequisite: good knowledge in population genetics and some experience in using GIS and R is required.

This course provides laboratory training for advanced students (master, doctoral or post-doctoral level). Different DNA/RNA extraction protocols, quality control measurements, SNP genotyping and gene expression techniques will be addressed. This is a course for practitioners.

To learn and improve on standard and modern methods of genetic data collection. With a focus on: Use of different extraction protocols, techniques for quality control measurements, gene expression, pyrosequencing and other SNP genotyping techniques.

No enrollment possible after 31.10.22. 

Number of participants limited to 8.

Waiting list will be deleted 19.01.2023.

This five-day winter school aims at teaching advanced Master students, PhD students and postdoctoral researchers on aspects of the Genomics of Environmental Adaptation. It provides both theoretical background and hands-on exercises on major topics of contemporary environmental genomics such as signatures of selection, outlier analysis, environmental association analysis or GWAS.

Genomics of environmental adaptation is an evolving scientific field of both basic and applied interest. Researchers make increasing use of diverse methodological approaches built on concepts from ecology, evolutionary biology and population genomics. This winter school introduces students to some major concepts and methods of environmental genomics, i.e., (i) how the environment and adaptive genetic variation relate and (ii) how signatures of genomic adaptation can be detected in natural populations. The winter school focuses on currently used methods and hands-on exercises, emphasizing an understanding of the underlying concepts and a discussion of benefits, limitations and pitfalls of environmental genomics. It is specifically aimed at the needs of advanced Master students, PhD students and early postdoctoral researchers.

Minimum number of participants is 5.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses: - Pflanzen- und Vegetationsökologie - Systematische Botanik - Raum- und Regionalentwicklung - Naturschutz und Naturschutzbiole

Material will be handed out in course.

Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

No enrollment possible after 31.10.22. 

Number of participants limited to 14.

Waiting list will be deleted 08.11.22. No enrollment possible after 31.10.22.

This course provides laboratory training for advanced students (master, doctoral or post-doctoral level). Different DNA/RNA extraction protocols, quality control measurements, SNP genotyping and gene expression techniques will be addressed. This is a course for practitioners.

To learn and improve on standard and modern methods of genetic data collection. With a focus on: Use of different extraction protocols, techniques for quality control measurements, gene expression, pyrosequencing and other SNP genotyping techniques.

Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

No enrollment possible after 31.10.22. 

Material will be handed out in course.

Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

No enrollment possible after 31.10.22. 

Material will be handed out in course.

Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

No enrollment possible after 31.10.22. 

Material will be handed out in course.

Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

No enrollment possible after 31.10.22. 

Material will be handed out in course.

Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).

No enrollment possible after 31.10.22. 

Material will be handed out in course.

Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course. It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).
Content
Topics:
(1) Neutral and adaptive genetic variation, neutral genetic structure; genomic markers and next generation sequencing techniques.
(2) Outlier analysis: concept and methodology of outlier analysis; diverse types of outlier analyses
(3) Environmental data: which environmental data are available and used to identify signatures of adaptation; data limitations; collinearity.
(4) Environmental association analysis (landscape genomics): concept and types of environmental association analysis; genomic offset.
(5) Genotypes and phenotypes: GWAS; follow-up analyses

Lecture notes
Hand-outs will be distributed.

Literature
The course requires 4 hours of preparatory reading of selected papers on the genomics of environmental adaptation. The papers will be distributed by e-mail.

Prerequisites / notice
Grading will be according to a written report (6-8 pages), in which students will have to design a complete study in environmental genomics, and according to student contributions during the course.
Prerequisites: students must have good knowledge in population genetics and evolutionary biology and basic skills in R; experience with GIS is advantageous.

701-1401-00L | Ecology and Evolution: Interaction Seminar | W | 2 credits | 2S | A. Hall
--- | --- | --- | --- | ---
Abstract
Interaction seminar. Student-mediated presentations, guests and discussions on current themes in ecology, evolutionary and population biology.

Objective
Getting familiar with scientific arguments and discussions. Overview of current research topics. Making contacts with fellow students in other groups.

Content
Scientific talks and discussions on changing subjects.

Lecture notes
None

Literature
None

Prerequisites / notice
For information, location and details: https://pe.ethz.ch/education/zis.html

Environmental Systems Policy

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1651-00L</td>
<td>Environmental Governance</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>E. Lieberherr</td>
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</table>

Priority is given to the target groups until 19.09.2022,

Target groups:
Environmental Sciences MSc
Agricultural Sciences MSc

Waiting list will be deleted on 23.09.2022

Abstract
The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

Objective
To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To analyze the evolution as well as the key elements of environmental governance.

Content
Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Lecture notes
Lecture slides, a script and additional course material will be provided on Moodle.

Prerequisites / notice
A detailed course schedule will be made available at the beginning of the semester. During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)
Objectives

- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content

Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies. The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes

Reader with issue-specific articles. E-version is partly available on Moodle

Literature

Aerni, P. (2021b) ‘Decentralized economic ecosystems in Switzerland and their contribution to inclusive and sustainable change’. Sustainability 13(8), 4181
Aerni, P. 2016a. Coping with Migration-Induced Urban Growth: Addressing the Blind Spot of UN Habitat. Sustainability 8(800)

Prerequisites / notice

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester. The class will be taught in English.

Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material.
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion.

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

Does not take place this semester.
At the end of the course, students:
- know core concepts of sustainable development, main features of social justice in the context of sustainability, a selection of methodologies for the assessment of sustainable development
- have a deepened understanding of the challenges of trade-offs between the different dimensions of sustainable development and their respective impacts on individual and societal decision-making

The course is structured as follows:
- overview of rationale, objectives, concepts and origins of sustainable development (approx. 15%)
- overview of the concept of social justice as guiding principle of the social dimension of sustainability (approx. 20%)
- analysis of a selection of concepts and methodologies to assess sustainable development in a variety of contexts (approx. 65%)

Students should be able to
a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental wellbeing. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

This course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.

The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.
The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors’ behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of ‘environmental governance’ and how legitimate and effective are these approaches in addressing persistent environmental challenges?

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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This course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

Students will be familiar with basic and advanced applications of stable isotopes in studies on plants, soils, water and trace gases, know the relevant approaches, concepts and recent results in stable isotope ecology, know how to combine classical and modern techniques to solve ecophysiological or ecological problems, learn to design, carry out and interpret a small IsoProject; practice to search and analyze literature as well as to give an oral presentation.

The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

The course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

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<tr>
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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Method-specific Competencies</td>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>
Abstract
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

Objective
The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation. Students should know at the end of the course:
1. Basics of measurement principle
2. Fundamentals of image acquisition
3. Basics of the sensor-specific geometries
4. Sensor-specific determination of environmental parameters

Content
Die Lehrveranstaltung gibt einen Einblick in die heutige Erdbefundung mit dem folgenden skizzierten Inhalt:
1. Einführung in die Fernerkundung von Luft- und Weltraum gestützten Systemen
2. Einführung in das Elektromagnetische Spektrum
3. Einführung in optische Systeme (optisch und hyperspektral)
4. Einführung in Mikrowellen-Technik (aktiv und passiv)
5. Einführung in atmosphärische Systeme (meteo und chemisch)
6. Einführung in die Techniken und Methoden zur Bestimmung von Umweltparametern
7. Einführung in die Anwendungen zur Bestimmung von Umweltparametern in der Hydrologie, Glaziologie, Forst und Landwirtschaft, Geologie und Topographie

Lecture notes
Folien zu jeden Vorlesungsschritt werden zur Verfügung gestellt.

Literature
Ausgewählte Literatur wird am Anfang der Vorlesung vorgestellt.

701-1776-00L  Geospatial Data Processing with Python and ArcGIS  W  1 credit  2U  A. Baltensweiler
Number of participants limited to 30.

Abstract
Waiting list will be deleted 13.09.2022.
The course communicates the basics of the programming language Python and gives a general introduction into the geoprocessing framework of ArcGIS. In addition various Python libraries (numpy, Scipy, GDAL, statsmodels, pandas, Jupyter Notebook) will be introduced which increase the functional range of the geoprocessing framework substantially.

Objective
The students learn the basics of geographic data processing based on the programming language Python and ArcGIS (arcpy). They get the ability to implement their own processing sequences and models for geoprocessing. The students are able to integrate open source libraries in their Python scripts and know how the libraries are applied to spatial datasets.

Content
The course communicates a deepened understanding of the geoprocessing frameworks arcpy and covers basic language concepts of Python such as datatypes, control structures and functions. In addition the application of popular Python libraries in combination with spatial datasets will be shown.

Lecture notes
Lecture notes, exercises and worked out solutions to them will be provided.

Literature

Prerequisites /
Basic knowledge of ArcGIS is assumed.

701-1682-00L  Dendroecology  W  3 credits  3G  C. Bigler, K. Treydte, G. von Arx

Abstract
The course dendroecology offers theoretical and practical aspects of dendrochronology. The impact of different environmental influences on tree-ring characteristics will be shown. The students learn various methods to date tree rings and they understand how ecological and environmental processes and patterns can be reconstructed using tree rings.

Objective
The students:
- understand, how wood is configured and how tree-ring structures are formed.
- are able to identify and describe different tree-ring structures.
- understand the theoretical and practical aspects of the dating of tree rings.
- know the effects of different abiotic and biotic environmental influences (climate, site, competition, insects, fire, physical-mechanical influences) on trees and tree rings.
- discover a tool for understanding and reconstructing global change processes.
- learn software to date, standardize and analyze tree rings.
- get hands-on experience based on the demonstration of wood (increment cores, stem discs, wedges), sampling in the field, and measuring and dating of tree rings in the tree-ring lab.
- solve R-based exercises (R tutorial will be provided) and answer questions in Moodle.
- work out an independent research question related to a dendroecological topic and write a short literature review based on scientific papers.

Content
- Overview and history of dendrochronology
- Principles of dendrochronology
- Formation and structure of wood and tree rings
- Wood anatomy and intra-seasonal tree-ring growth
- Continuous and discontinuous tree-ring characteristics
- Sampling and measuring of tree rings
- Crossdating methods (visual, skeleton plots, quantitative)
- Detrending and standardization of tree-ring series
- Development of tree-ring chronologies
- Water transport in trees
- Stable isotopes in tree rings
- Climate influences, climate-growth relationships, climate reconstructions
- Reconstruction of forest dynamics (regeneration, growth, competition, mortality)
- Disturbance ecology (fire, insects, blowdown)
- Application of tree-ring research in practice and in interdisciplinary research projects
- Field and lab day (date for one entire day or two half days will be searched together with the students in the beginning of the semester): discussion of different dendroecological questions in the forest; sampling of trees; insight into different tree-ring projects in the lab (Swiss Federal Institute for Forest, Snow and Landscape Research WSL)

Lecture notes
Lecture notes (in English) will be handed out in the class.

The lecture notes and further documents (papers, software) can be downloaded from Moodle (https://moodle-app2.let.ethz.ch) following registration for the course.

Literature
Literature lists will be handed out in the class.
This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance. Master and PhD students are introduced to current areas of research in soil sciences and get first-hand experience in scientific discussion.

### Content
The seminar covers the following topics:
1. (1) Theories and concepts of inter- and transdisciplinary research
2. (2) The specific challenges of inter- and transdisciplinary research
3. (3) Collaborating between different disciplines
4. (4) Engaging with stakeholders
5. (5) 10 steps to make participants’ research projects more societally relevant

Throughout the whole course, scientific literature will be read and discussed as well as practical tools explored in class to address concrete challenges.

### Literature
The following open access article builds a core element of the course:
Available at (open access): http://www.ingentaconnect.com/contentone/oekom/gaia/2017/00000026/00000001/art00011

Further, this collection of tools will be used:
https://naturalsciences.ch/topics/co-producing_knowledge

### Prerequisites / notice
Participation in the course requires participants to be working on their own research project.

### Dates (Wednesdays, 8h15-12h00): 28 September, 12 October, 26 October, 9 November, 23 November

### Fostered competencies
- Subject-specific Competencies: Concepts and Theories, Problem-solving
- Method-specific Competencies: Analytical Competencies, Problem-solving, Project Management
- Social Competencies: Cooperation and Teamwork, Sensitivity to Diversity
- Personal Competencies: Critical Thinking, Self-awareness and Self-reflection

### Invited external speakers present their research on current issues in the field of soil science and discuss their results with the participants.

Master and PhD students are introduced to current areas of research in soil sciences and get first-hand experience in scientific discussion.

### Inter- and Transdisciplinary Courses

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<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-0015-00L</td>
<td>Interdisciplinarity and Stakeholder Engagement</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>B. Vienni Baptista, C. E. Pohl, M. Stauffacher</td>
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### Basic and Scientific Skills

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<tbody>
<tr>
<td>701-0019-00L</td>
<td>Readings in Environmental Thinking</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>J. Ghazoul</td>
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</tbody>
</table>

### Prerequisites / notice
Number of participants limited to 20. Waiting list will be deleted 30.09.2022.

### Abstract
This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance, and shaped its relevance to society. Above all, the course seeks to give confidence and raise enthusiasm among students to read more widely around the broad subject of environmental sciences and management both during the course and beyond.

### Objective
The course will provide students with opportunities to read, discuss, evaluate and interpret key texts that have shaped the environmental movement and, more specifically, the environmental sciences. Students will gain familiarity with the foundational texts, but also understand the historical context within which their academic and future professional work is based. More directly, the course will encourage debate and discussion of each text that is studied, from both the original context as well as the modern context. In so doing students will be forced to consider and justify the current societal relevance of their work.
The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion.

Thereafter, in each week a text (typically a chapter from a book or a paper) considered to be seminal or foundational will be assigned by a course lecturer. The lecturer will introduce the selected text with a brief background of the historical and cultural context in which it was written, with some additional biographical information about the author. He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session. Presentation of the text requires the students to prepare by, for example:

- identifying the key points made within the text
- identifying issues of particular personal interest and resonance
- considering the impact of the text at the time of publication, and its importance now
- evaluating the text from the perspective of our current societal and environmental position

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

The specific texts selected for discussion will vary, but examples include:

- Leopold (1949) A Sand County Almanach
- Carson (1962) Silent Spring
- Jared Diamond (2005) Collapse

Discussions might also encompass films or other forms of media and communication about nature.

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701-3001-00L Environmental Systems Data Science: Data Processing

"Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar."

Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022.

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
- The students are able to:
  - frame a data science problem and build a hypothesis
  - describe the steps of a typical data science project workflow
  - conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
  - critically think about the limits and implications of a method
  - visualise data and results throughout the workflow
  - access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

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851-0180-00L Research Ethics

Number of participants limited to 40

Particularly suitable for students of D-BIOL, D-CHAB, D-HEST

Abstract
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.
Participants of the course Research Ethics will
• Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
• Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and
  principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own
  reasoning to the kinds of ethical problems a scientist is likely to encounter;

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice
(QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research
wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5
Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research
ethical 1.4 Social value and scientific validity 1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio
1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a
whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3
Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Controversing science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic
biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course
homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific
learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research
Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!)
connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class),
solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even
more…).

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed

Transferable Skills

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-5001-00L</td>
<td>Ethics and Scientific Integrity for Doctoral Students</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>N. Gruber, E. Lieberherr, A. Widmer</td>
</tr>
</tbody>
</table>

Abstract
This course sensitises doctoral students to ethical issues that may arise during their doctorate. After an introduction to ethics and good
scientific practice, students are familiarised with resources that can assist them with ethical decision-making. Students are given the
opportunity to apply their knowledge and train their newly acquired skills in an interactive, discipline specific context.

Objective
Doctoral students learn how to identify, analyse and address ethical issues in their own scientific research. Furthermore, they are
encouraged to reflect on their professional role as scientific researchers.
Part I
The self-paced e-learning course consists of 5 modules:

Module 1: Ethics
Introduction to moral theory (with emphasis on practical guidance regarding decision making)

Module 2: Ethics in scientific research
Introduction to ethical issues that occur within scientific research (i.e. regarding authorship, cooperation, data use and sharing, and other aspects that are subject to scientific integrity and good scientific practice).

Module 3: Collecting resources
A variety of tools and resources that help identify ethical issues are presented and explained

Module 4: Setting up a strategy
Example examination of a case regarding its ethical scope (students develop their own strategy to examine situations for their ethical implications).

Module 5: Making decisions
Different ways of addressing ethical issues are presented and explained (i.e. how to make hard choices or solve ethical dilemmas).

Part II
The second, face-to-face part of this course focuses on discipline-specific aspects in the general area of Environmental Sciences. It provides an interactive learning environment. Students get to apply their knowledge, and they are encouraged to reflect on ethical problems and to critically discuss them with fellow doctoral students.

Prerequisites / notice
For doctoral students only

Fostered competencies
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<tr>
<th>Subject-specific Competencies</th>
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<th>Personal Competencies</th>
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900-0100-DRL Transferable Skills Course I (1-3 days)
W 1 credit 2S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0101-DRL Transferable Skills Course II (1-3 days)
W 1 credit 2S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0102-DRL Transferable Skills Course III (1-3 days)
W 1 credit 2S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days.

900-0103-DRL Transferable Skills Course I (1-3 days, with Poster or Talk)
W 2 credits 4S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

Objective
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

900-0104-DRL Transferable Skills Course II (1-3 days, with Poster or Talk)
W 2 credits 4S Lecturers
Only for doctoral students.

Abstract
Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.
**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of short courses or workshops with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion.

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<td>4S</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

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<td>Transferable Skills Course III (min 4 days)</td>
<td>2 credits</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days.

**Objective**

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**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

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Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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<tr>
<td>900-0111-DRL</td>
<td>Transferable Skills Course III (min 4 days, with Poster or Talk)</td>
<td>3 credits</td>
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<td>Lecturers</td>
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Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

**Abstract**

Acquisition of transferable skills and cross-disciplinary competences in the range of courses or workshops with a minimum duration of 4 days. Participants need to present either a poster or a talk at this occasion.

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<td>Participation in Commission I (min 1 year)</td>
<td>1 credit</td>
<td>2P</td>
<td>Lecturers</td>
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</tbody>
</table>

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.
Abstract
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0113-DRL Participation in Commission II (min 1 year) W 1 credit 2P Lecturers

Abstract
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Active participation in commissions or university bodies, like associations of scientific staff, the university assembly or similar for at least 1 year.

900-0114-DRL Member of Executive Board (min 1 year) W 2 credits 4P Lecturers

Abstract
Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Objective
Active participation in the presidium or executive board of a university group for at least 1 year.

Integration into Scientific Community

<table>
<thead>
<tr>
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</table>

| 900-0151-DRL Summer School II (1-3 days) | W    | 1 credit | 2K | Lecturers |
| Abstract | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective | Participation in summer or winter schools with a maximum duration of 3 days. |

| 900-0152-DRL Summer School III (1-3 days) | W    | 1 credit | 2K | Lecturers |
| Abstract | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective | Participation in summer or winter schools with a maximum duration of 3 days. |

| 900-0153-DRL Summer School I (1-3 days, with Poster or Talk) | W    | 2 credits | 4K | Lecturers |
| Abstract | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

| 900-0154-DRL Summer School II (1-3 days, with Poster or Talk) | W    | 2 credits | 4K | Lecturers |
| Abstract | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |

<p>| 900-0155-DRL Summer School III (1-3 days, with Poster or Talk) | W    | 2 credits | 4K | Lecturers |
| Abstract | Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate. |
| Objective | Participation in summer or winter schools with a maximum duration of 3 days. Participants need to present either a poster or a talk at this occasion. |</p>
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</table>
Only for doctoral students.

Please select your doctoral thesis supervisor as a lecturer and prove your participation with the appropriate certificate.

Abstract
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

Objective
Participation in conferences outside ETH to foster scientific exchange. Participants need to present either a poster or a talk at this occasion.

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<td>D</td>
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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Electrical Engineering and Information Technology Bachelor

## 1st Semester

### First Year Examinations

#### First Year Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>227-0003-00L</td>
<td>Digital Circuits</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Luisier</td>
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</tbody>
</table>

**Abstract**

Digital and analogue signals and their representation, logic gates, transistors, combinational and sequential circuits and systems, boolean algebra, Karnaugh-maps, finite state machines, memory and computing building blocks in CMOS technology.

**Objective**

Provide basic knowledge and methods to understand and to design digital circuits and systems.

**Content**

Digital and analogue signals and their representation. Boolean Algebra, circuit analysis and synthesis, the MOS transistor, CMOS logic, static and dynamic behaviour, Karnaugh-Maps, hazards, binary number systems, coding. Combinational and sequential circuits and systems (boolean algebra, K-maps, etc.). Memory building blocks and memory structures, programmable logic circuits. Finite state machines, architecture of microprocessors.

**Lecture notes**

Lecture notes for all lessons, assignments and solutions.

**Literature**


**Prerequisites / notice**

No special prerequisites.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Critical Thinking</td>
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<td>Self-direction and Self-management</td>
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</table>

**Abstract**

Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.

**Objective**

Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte.

**Lecture notes**

eigenes Aufschrieb und K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002

**Literature**

K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002

**Fostered competencies**

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<td>C. Franck</td>
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</table>

**Abstract**

This course introduces the students into the basics of electric circuits, the underlying physical phenomena and required mathematical methods.

**Objective**

Voltage, current and properties of basic elements of electric circuits, i.e. capacitors, resistors and inductors should be understood in relation to electric and magnetic fields. Furthermore, the students should be able to mathematically describe, analyze and finally design technical realizations of circuit elements. Students should also be familiar with the calculation of voltage and current distributions of DC circuits. The effect and the mathematical formulation of magnetic induction should be known for technical applications.

**Content**

Electrostatic field; Stationary electric current flow; Basic electric circuits; current conduction mechanisms; time variant electromagnetic field.

**Lecture notes**

Manfred Albach, Elekrotechnik ISBN 978-3-86894-398-6 (2020) and lecture notes

**Literature**

Manfred Albach, Elekrotechnik 978-3-86894-398-6 (2020)
Fostered competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies

- Analytical Competencies not assessed
- Decision-making not assessed
- Media and Digital Technologies not assessed
- Problem-solving not assessed

Social Competencies

- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies

- Adaptability and Flexibility not assessed
- Creative Thinking not assessed
- Critical Thinking not assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

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151-0223-10L Engineering Mechanics

**Abstract**
Introduction to engineering mechanics: kinematics, statics and dynamics of rigid bodies and systems of rigid bodies.

**Objective**
Students can solve problems of elementary engineering mechanics.

**Content**
Basic notions: position and velocity of particles, rigid bodies, planar motion, kinematics of rigid body, force, couple, power. Statics: static equivalence, force-couple system, center of forces, centroid, principle of virtual power, equilibrium, constraints, statics, friction. Dynamics: acceleration, inertial forces, d'Alembert's Principle, Newton's Second Law, principles of linear and angular momentum, equations of planar motion of rigid bodies.

**Lecture notes**
yes, in German

**Literature**

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**First Year Examination Block B**

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<td>8</td>
<td>4V+3U</td>
<td>T. Rivière</td>
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</table>

**Abstract**
Reelle und komplexe Zahlen, Grenzwerte, Folgen, Reihen, Potenzreihen, stetige Abbildungen, Differential- und Integralrechnung einer Variablen, Einführung in gewöhnliche Differentialgleichungen

**Objective**
Einführung in die Grundlagen der Analysis

**Lecture notes**
Christian Blatter: Ingenieur-Analysis (Kapitel 1-4)

**Literature**
Konrad Koenigsberger, Analysis I.
Christian Blatter, Analysis I.

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**First Year Compulsory Laboratory Courses**

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<td>227-0005-10L</td>
<td>Digital Circuits Laboratory ▪</td>
<td>O</td>
<td>1</td>
<td>1P</td>
<td>A. Emboras, M. Luisier</td>
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</tbody>
</table>

**Abstract**
Digital and analogue signals and their representation. Combinational and sequential circuits and systems, boolean algebra, Karnaugh-maps. Finite state machines. Memory and computing building blocks in CMOS technology, programmable logic circuits.

**Objective**
Deepen and extend the knowledge from lecture and exercises, usage of design software Quartus II as well as an oscilloscope

**Content**
The contents of the digital circuits laboratory will deepen and extend the knowledge of the correspondent lecture and exercises. With the help of the logic device design software Quartus II different circuits will be designed and then tested on an evaluation board. You will build up the control for a 7-digit display as well as an adder and you will create different types of latches and flip-flops. At the end of the laboratory a small synthesizer will be programmed that is able to play self-created melodies. At the same time the usage of a modern oscilloscope will be taught in order to analyse the programmed circuits through the digital and analogue inputs.

**Lecture notes**
Lecture notes for all experiments.
https://iis-students.ee.ethz.ch/lectures/digital-circuits/praktikum/

**Prerequisites / notice**
No special prerequisites
<table>
<thead>
<tr>
<th></th>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Techniques and Technologies</th>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Cooperation and Teamwork</td>
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<td>Critical Thinking</td>
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<tr>
<th>Course Code</th>
<th>Preparatory Course in Computer Science</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturer</th>
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<tr>
<td>252-0865-00L</td>
<td>O</td>
<td>1</td>
<td>1P</td>
<td>M. Schwerhoff</td>
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</table>

**Abstract**

The course provides an elementary introduction to programming with C++. Prior programming experience is not required.

**Objective**

Establish an understanding of basic concepts of imperative programming and how to systematically approach programming problems. Students are able to read and write simple C++ programs.

**Content**

This course introduces you to the basics of programming with C++. Programming means instructing a computer to execute a series of commands that ultimately solve a particular problem.

The course comprises the following:
- General introduction to computer science: development, goals, fundamental concepts
- Interactive self-study tutorial that provides an introduction to C++ and covers the following topics: variables, data types, conditional statements and loops
- Introduction to stepwise refinement as an approach to systematically solving programming problems
- Two small programming projects, to practically apply the studied fundamentals

**Lecture notes**

All teaching material is available online; an online development environment is used for the programming projects.

---

## 3rd Semester: Examination Blocks

### Examination Block 1

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0353-00L</td>
<td>Analysis 3</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>M. Iacobelli</td>
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</table>

**Abstract**

In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

**Objective**

The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

**Content**

1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)

2.) Quasilinear first order PDEs
   - Solution with the method of characteristics
   - Conservation laws

3.) Hyperbolic PDEs
   - wave equation
   - d'Alembert formula in (1+1)-dimensions
   - method of separation of variables

4.) Parabolic PDEs
   - heat equation
   - maximum principle
   - method of separation of variables

5.) Elliptic PDEs
   - Laplace equation
   - maximum principle
   - method of separation of variables
   - variational method

**Literature**


**Prerequisites / notice**

Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturer</th>
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<tr>
<td>401-0353-00L</td>
<td>Physics II</td>
<td>O</td>
<td>8</td>
<td>4V+2U</td>
<td>J. Faist</td>
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</table>

**Abstract**

The goal of the Physics II class is an introduction to quantum mechanics.

To work effectively in many areas of modern engineering, such as renewable energy and nanotechnology, students must possess a basic understanding of quantum mechanics. The aim of this course is to provide this knowledge while making connections to applications of relevancy to engineers. After completing this course, students will understand the basic postulates of quantum mechanics and be able to apply mathematical methods for solving various problems including atoms, molecules, and solids. Additional examples from engineering disciplines will also be integrated.
Modern, transistor-based electronics has transformed our lives and plays a crucial role in our economy since the 2nd half of last century. The main objective of this course in electronic circuits is to introduce the concept of the active device, including operational amplifiers, and their use in amplification, signal conditioning, switching and filtering to students. In addition to gaining experience with typical electronic circuits that are found in common applications, including their own Gruppenarbeit and Fachpraktikum projects, students sharpen their understanding of linear circuits based on nonlinear devices, imperfections of electronic circuits and the concept of design (as opposed to analysis). The course is a prerequisite for higher semester subjects such as analog integrated circuits, RF circuits for wireless communications, A/D and D/A converters and optoelectronics.

**Objective**


**Content**

- Review of transistor devices (bipolar and MOSFET), large signal and small signal characteristics, biasing and operating points.
- Single transistor amplifiers, simple feedback for bias stabilization.
- Frequency response of simple amplifiers.
- Broadbanding techniques.
- Differential amplifiers, operational amplifiers, variable gain amplifiers.
- Instrumentation amplifiers: common mode rejection, noise, distortion, chopper stabilization.
- Transimpedance amplifiers.
- Active filters: simple and biquadratic active RC-filters, higher order filters, biquad and ladder realizations.
- Switched-capacitor filters.

**Literature**


**Prerequisites**

Prerequisite: Computer Science I
Modern, transistor-based electronics has transformed our lives and plays a crucial role in our economy since the 2nd half of last century. The main objective of this course in electronic circuits is to introduce the concept of active device, including operational amplifiers, and their use in amplification, signal conditioning, switching and filtering to students. In addition to gaining experience with typical electronic circuits that are found in common applications, including their own Gruppenarbeit and Fachpraktikum projects, students sharpen their understanding of linear circuits based on nonlinear devices, imperfections of electronic circuits and the concept of design (as opposed to analysis). The course is a prerequisite for higher semester subjects such as analog integrated circuits, RF circuits for wireless communications, A/D and D/A converters and optoelectronics.

Get to know and understand basic transistor and op amp based electronic circuits. Build and operate simple electronic circuits including supply decoupling. Carry out and understand different, principal measurement methods such as DC- and AC-analysis, time and frequency domain measurements, impedance and transfer function measurements. In the lab we will have a closer look at the following topics and circuits: characterization of a real capacitor including non-idealities; common-emitter transistor amplifier with emitter degeneration; characterization of a real operational amplifier with non-idealities; band pass filter with op amp, resistors and capacitors; data converters; oscillator and function generator based on an op amp.

Laboratory Courses, Projects, Seminars
A minimum of 15 cp (under the 2018 regulations), respectively at least 18 cp (under the 2016 regulations) must be achieved in the category "Laboratory Courses, Projects, Seminars".

General Laboratory

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<thead>
<tr>
<th>Number</th>
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<td>General Laboratory I</td>
<td>W</td>
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<td>Only for Electrical Engineering and Information Technology BSc.</td>
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<td>Enrolment via Online-Tool (EE-Website: Studies -&gt; Bachelor Program -&gt; Third Year -&gt; Laboratory Courses)</td>
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<td>The Laboratory courses in the 5th and 6th semesters enable the students to put the the contents of the courses from the four first semesters to the test and to consolidate the acquired knowledge. Furthermore students have the possibility to gain specific knowledge in certain software packages as MATLAB.</td>
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<td>Implementing the knowledge acquired during the basic studies.</td>
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<td>Prerequisites / notice</td>
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<td>Enrolment via Online-Tool (EE-Website: Studies -&gt; Bachelor Program -&gt; Third Year -&gt; Laboratory Courses)</td>
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<td>Prerequisites / notice</td>
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Projects & Seminars
Enrolment is only possible for students in the BSc Electrical Engineering and Information Technology from Friday before the start of the semester. Places are allocated using the P&S application tool (https://psapp.ee.ethz.ch/). Please only enrol for P&S for which you apply via the tool.

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<th>Number</th>
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<td>227-0085-01L</td>
<td>Projects &amp; Seminars: Amateur Radio Course</td>
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<td>1.5 credits</td>
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<td>J. Leuthold</td>
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<td>Only for Electrical Engineering and Information Technology BSc.</td>
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<td>The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.</td>
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<td></td>
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<tr>
<td></td>
<td>The category of &quot;Laboratory Courses, Projects, Seminars&quot; includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.</td>
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<td>Der Amateurfunk ermöglicht es, drahtlos über weite Distanzen zu kommunizieren.</td>
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<td>Doch darf eine Amateurfunk-Station nicht ohne Weiteres betrieben werden.</td>
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<td>Voraussetzung ist das Ablegen der Amateurfunkprüfung HB3 oder HB9 beim BAKOM.</td>
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<td>In diesem Kurs werden wir einen Überblick über die wichtigsten Themengebiete des Amateurfunks bieten.</td>
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<td>Im praktischen Teil werdet ihr unter anderem die Gelegenheit haben, das Funkgerät selbst in die Hand zu nehmen.</td>
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<td>In einem Portabel-Ausflug (nicht testatpflichtig) werden wir zudem draussen eine mobile Funkstation aufbauen und bedienen.</td>
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<td>Nach dem Kurs habt ihr die Möglichkeit, die HB9-Prüfung abzulegen.</td>
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<td>Mit der Prüfung in der Tasche könnt ihr dann auch die Funkbude des AMIV auf dem ETZ-Dach verwenden oder auch eure eigene Anlage aufbauen und betreiben.</td>
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<td>Voraussetzung für das Testat ist eine aktive Teilnahme am Kurs, nicht das Bestehen der BAKOM-Prüfung.</td>
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<td>Eine erfolgreiche Funkverbindung zu einer anderen Station ist ebenfalls Teil der Testatbedingung.</td>
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<td>Das Lernmaterial wird in der ersten Kursstunde ausgegeben.</td>
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<tr>
<td>227-0085-02L</td>
<td>Projects &amp; Seminars: Game Development with Unity</td>
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<td>Only for Electrical Engineering and Information Technology BSc.</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 876 of 2416
The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
Game Development is a big field and is constantly growing. A powerful tool to create cross-platform games is Unity. Unity is a cross-platform real-time game engine that uses C# as its programming language (very similar to Java). This P&S is a great chance for gaining practical experience, creating something from scratch and establishing a supporting community. Therefore, if you are eager to improve your coding skills as well as bring them to life by applying them to game development, this is the right P&S for you!

227-0085-03L Projects & Seminars: COMSOL Design Tool – Design of Optical Components  
W 3 credits 3P J. Leuthold  

Does not take place this semester.  
Only for Electrical Engineering and Information Technology BSc.

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
Simulation tools are becoming an essential accessory for scientists and engineers for the development of new devices and study of physical phenomena. More and more disciplines rely on accurate simulation tools to get insight and also to accurately design novel devices.

COMSOL is a powerful multiphysics simulation tool. It is used for a wide range of fields, including electromagnetics, semiconductors, thermodynamics and mechanics. In this P&S we will focus on the rapidly growing field of integrated photonics.

During hands-on exercises, you will learn how to accurately model and simulate various optical devices, which enables high-speed optical communication. At the end of the course, students will gain practical experience in simulating photonic components by picking a small project in which certain photonic devices will be optimized to achieve required specifications. These simulated devices find applications in Photonic Integrated Circuits (PICs) on chip-scale.

Prerequisites / notice
Course website: https://blogs.ethz.ch/ps_comsol  
No previous knowledge of simulation tools is required. A basic understanding of electromagnetics is helpful but not mandatory. The course will be taught in English.

227-0085-04L Projects & Seminars: Microcontrollers for Sensors and Internet of Things  
W 4 credits 4P M. Magno  

Only for Electrical Engineering and Information Technology BSc.

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
Ultra Low Power Microcontroller (MCU) – Firmware Programming and Sensors Interfacing using an Arm Cortex-M (STM32) Microcontroller

Microprocessors are used to execute big and generic applications, while microcontrollers are low cost and low power embedded chips with program memory and data memory built onto the system which are used to execute simple tasks within one specific application (i.e. sensor devices, wearable systems, and IoT devices). Microcontrollers demand very precise and resource-saving programming, therefore it is necessary to know the processor core, and particular importance has the investigation of the microcontroller's hardware components (ADC, clocks, serial communication, timers, interrupts, etc.).

The STM32 from STMicroelectronics has gained in popularity in recent years due to its low power and ease of use. The goal of this course is the development of understanding the internal processes in the microcontroller chip from T1. This will enable you to conduct high-level firmware-programming of microcontrollers, to learn about the STM32 MCU, its benefits, and programming and how they can be connected with sensors, acquire the data, processing them and send the information to other devices. The course will also include an introductory lecture on machine learning and artificial intelligence on the embedded system and in particular microcontrollers. The C language will be used to program the microcontroller.

The course will be taught in English.

227-0085-05L Projects & Seminars: FPGA in Quantum Computing with Superconducting Qubits  
W 3 credits 3P M. Magno, A. Akin  

Only for Electrical Engineering and Information Technology BSc.

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
FPGAs are used in wide range of applications including video processing, machine learning, cryptography and radar signal processing, thanks to their flexibility and massive parallel processing power. Recently FPGAs have become important in quantum signal processing where high amount of data should be analyzed in a short time to use quantum setups most efficiently. In addition, FPGAs are used for quantum state detection and feedback generation, which have to be performed in the scale of hundreds of nanoseconds. The goal of this course is to understand the FPGA based signal processing for superconducting circuits based quantum experiments. The course participants will learn the implementation techniques of the modules for fast quantum signal acquisition and processing, the electronics supporting quantum experiments, and FPGA programming. You will implement quantum signal processing and quantum state detection modules using Xilinx FPGA, Verilog HDL, and high speed ADC. The course will be taught in English. No prior knowledge in quantum physics or FPGA is required, still a good knowledge in any coding language (for example C or Java) is required.

227-0085-06L Projects & Seminars: Neural Network on Low Power FPGA: A Practical Approach  
W 2 credits 2P  

Does not take place this semester.
Artificial Intelligence and in particular neural networks are inspired by biological systems, such as the human brain. Through the combination of powerful computing resources and novel architectures for neurons, neural networks have achieved state-of-the-art results in many domains such as computer vision. FPGAs are one of the most powerful platform to implement neural networks as they can handle different algorithms in computing, logic, and memory resources in the same device. Faster performance comparing to competitive implementations as the user can hardcode operations into the hardware. This course will give to the student the basis of Machine Learning to understand how they work and how they can be trained and giving hand-on experiences with the training tools such as Keras. Moreover the course will focus in deploy algorithms in low power FPGA such as the Lattice sensAI platform to have energy efficient running algorithms. The course will provide to the students the tools and know-how to implement neural netwok on an FPGA, and the student will challenge theirselves in a 5 weeks piratical project that they will present at the end of the course. Experience in FPGA programming is desirable but not mandatory.

The course will be taught in English.

### 227-0085-08L
**Projects & Seminars: Bluetooth Low Energy Programming for IoT Sensing System**

*Does not take place this semester.*

**Objective**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Abstract**

Bluetooth Low Energy System on Chip – Firmware Programming and sensors Interfacing using an Arm Cortex-M (Nordic nrf52838) Microcontroller

With the introduction of the BLE 5.0 standard, Bluetooth has achieved high data bandwidth with low power consumption. This makes the technology an ideal match for many applications, i.e., IoT sensor application or audio streaming, by addressing two of the greatest bottlenecks of these devices. This course offers the chance for participants to do hands-on programming of microcontrollers. In particular, the focus will be laid on interfacing with sensors, acquisition of data, on-board event-driven data processing with ARM-Cortex-M4 processors and BLE or other wireless transmissions. The programming will be performed in C. Today’s microcontrollers offer a low power, efficient and cost-effective solution of tackling a nearly infinite number of task-specific applications. Ranging from IoT devices, wearable systems, sensor (mesh) devices, all the way to be integrated as submodules for the most complex system such as cars, planes, and rockets. Microcontrollers derive their advantages from the efficient use of resources and as such require very efficient and resource-saving programming. Therefore, it is mandatory to understand hardware components such as processor cores, ADC, clocks, serial communication, wireless communication, timers, interrupts, etc. The P&S includes five weeks project where the student will setup an IoT sensor node to monitor electric power transmission and distribution system.

The course will be taught in English by the ITET center for project based learning.

### 227-0085-09L
**Projects & Seminars: Spiking Neural Network on Neuromorphic Processors**

*Does not take place this semester.*

**Objective**


Compared to the "traditional" artificial neural network, the spiking neural network (SNN) can provided both latency and energy efficiency. Moreover, SNN has demonstrated in previous works a better performance in processing physiological information of small sample size, and only the output layer of the spiking neural network needs to be trained, which results in a fast training rate. This course focuses on giving the bases of spiking neural networks and neuromorphic processors. Students will learn the tools to implement SNN algorithm in both academic processors and Intel Loihi using data from Event-based Vision camera and biomedical sensors (i.e. ECG and EEG). The course will end with 4 weeks project where the students can target a specific application scenario.

The course will be taught in English.

### 227-0085-11L
**Projects & Seminars: Deep Learning for Image Manipulation (DLIM)**

*Does not take place this semester.*

**Objective**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

The course will be taught in English.
The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these courses encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

### Objective

The goal of this lab course is for the students to enhance their understanding on how basic analog electronic circuits work, or perhaps don’t work, and provide enough practical experience for the students to feel at ease using transistors, resistors, capacitors, diodes, etc., to create working circuits.

For example, students create circuits that make physical quantities audible. Students are encouraged to realize their own circuit ideas.

### Dates:


### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Project Management</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
</tr>
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<td></td>
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<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
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<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
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</tbody>
</table>

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

In order to introduce you to the capabilities of modern AFMs in biomedical sensing, you will build your own setups in groups of two. You will be introduced to an AFM’s functionality, control, and signal read-out using LabView. A signal of an oscillating tuning-fork will be used as feedback for the self-built AFM. In order to better understand the working principle of a tuning fork, you will also build your own frequency sweeper and analyze it with self-built low-pass filters.

After you have implemented your own setup, you will have the chance to investigate different biomedical samples on state-of-the-art setups. This data will then be analyzed using Python.

The focus of this P&S seminar is to enable you to transfer your theoretical knowledge into practice and at the same time get to know how electrical engineering can be used in biomedical research.

The course requires active participation during the practical sessions, a 10-15 min presentation and a short written report on the acquired results. The course will be given in English.
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allowing for explorative learning and teaching the methodology of project work.

Objective

More and more sustainable and renewable energy technologies are used for electricity generation to cope with climate change. These distributed resources transform the electric power grid and impose major challenges.

In this seminar, students have the opportunity to glance at cutting-edge research in the field of power systems. Possible research questions might be:

- How to integrate distributed energy generation like PV plants and wind turbines into the electricity grid?
- What challenges does the increasing share of electric vehicles and batteries impose on the power grid?
- How to cope with the uncertain generation capacity of renewables and how to forecast it?
- How does the electricity market work and how do the new sources of flexibility transform it?

Students will prepare a presentation and a report on their individual research question, which is based on an assigned paper. The main objectives are to practice literature review, scientific writing and presenting. Students will learn to independently understand specific research results – a crucial skill for academic research including semester and master projects.

The language of instruction is English. Registrations for the seminar are binding.
Digital communication is a part of our everyday lives, whether we are sending e-mails, watching TV, listening to the radio, or using a cell phone. In this P&S, we will familiarize ourselves with the basics of digital communication.

On conventional PCs, the students will implement their own software modems for data transmission. These modems, just like the digital communication systems used in real life, consist of a modulator, a demodulator and an algorithm to synchronize the carrier of the incoming message. Once implemented, these modems can be used to acoustically transmit any data (such as small text files) between PCs.

We use MATLAB but previous knowledge thereof is not assumed. Rather, the goal of the project is to practice programming with MATLAB in addition to learning basics of digital communication.

### Objective

The objective of this P&S is to make a real-world quad-rotor fly autonomously by applying the control and estimation theory taught in class.

A prior exposure to control theory (e.g. by attending a Control Systems course) is desirable. Those students who are not familiar with control theory will need to complete some extra study to understand some aspects of this P&S.

A basic knowledge of programming in Python and MATLAB is required.

The course is taught in English and open to 5th or higher semester students.

You are required to bring your own Laptop for the programming exercises.

### Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

### Objective

Wireless transmission of information is ubiquitous today. Depending on application and frequency range, different types of modulation are used, with digital methods having largely replaced the old analog methods. Software Defined Radio (SDR) tools make it possible to dive into this world and "surf the waves" with relatively little effort. More powerful computers allow for increasingly complex signal processing in transmitters and receivers. At the same time, the signal processing algorithms can be adapted and changed very quickly and flexibly.

In this P&S we will take a closer look at how SDR works. In the first part we will work on the basics of frequencies, spectra, modulation types, and signal processing.

In the second part we will work in groups on different projects with SDR tools. Students can also bring their own ideas. At the end, the projects will be presented in the class.

### Objective

The objective of this P&S is to make a real-world quad-rotor fly autonomously by applying the control and estimation theory taught in class.

A video showing highlights from HS2018 can be see here: http://www.youtube.com/watch?v=PEg-XHSXd58

In the first half of the P&S, we will introduce the physical model for a quad-rotor and use this to apply the control and estimation techniques that are taught in the 5th semester in the Control System 1 class. The students will then create their own control function for a quad-rotor and test these in simulation. The second half of the course will involve the students implementing the control and estimation algorithms they design in the real-world on our fleet of nano-quad-rotors. Once stable flight is achieved, the students will have the freedom to perform tasks with the quad-rotor. By implementing the control and estimation algorithms on a real-quadcopter, the students will gain experience with how decisions in the modeling and design stage affect real-world performance.

### Important Information:

Students must be in the 6th semester. The first class will be Monday, September 21 for all students. Classes will then occur every second week. The students will be split into two groups and the classes for each group will occur on alternating weeks.

It is preferable to be taking the Control Systems 1 (CS1) course but not mandatory. Those students who are not taking CS1 will need to complete some extra reading to understand some aspects of this P&S.

Due to COVID-19, the course will be offered in an online setting with classes being held over Zoom. The students will be able to take a real-world quad-rotor to their homes in order to familiarize themselves with the control and estimation algorithms taught in the course.

### Objective

Vision and Control in RoboCup is jointly offered by Prof. John Lygeros (IFA), Prof. Luc Van Gool (CVL) and Prof. Fisher Yu (CVL).

RoboCup is a tournament where teams of autonomous robots compete in soccer matches against each other. The ETH team NomadZ (https://robocup.ethz.ch/) plays in the Standard Platform League with a team of humanoid NAO robots, where the focus lies on developing robust and efficient algorithms for vision, control and behavior.

The main objective of this course is to familiarize students on the fundamental challenges we encounter in RoboCup. This is accomplished by a combination of lecture sessions, related student exercise sets and programming projects in MATLAB and Python. The topics cover visual localization, deep learning for object detection and reinforcement learning control of unknown systems.

### Important Information for Candidates:

You are required to bring your own Laptop for the programming exercises.

The course is taught in English and open to 5th or higher semester students. A basic knowledge of programming in Python and MATLAB is required. A prior exposure to control theory (e.g. by attending a Control Systems course) is desirable. Those students who are not familiar with control theory will need to complete some extra study to understand some aspects of this P&S.

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The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

The phenomenon of nuclear magnetic resonance (NMR) and its application for spectroscopy and imaging are introduced. The course starts with a general introduction to NMR, followed by measurements on a clinical MRI scanner. The NMR experiments will be developed and programmed by the students. Starting from a simple spectroscopic experiment, the basics of imaging will be acquired step-by-step. Finally, sectional images of test objects will be obtained.

The course will be conducted only if at least 2 participants show up. In case in-classroom teaching is not allowed, the course must be cancelled.

**Projects & Seminars: Biosignal Acquisition and Processing for IoT Wearable Devices**

*Does not take place this semester.*

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Biosignal acquisition and processing – Wearable sensor node design and analysis for bio-impedance sensor using an Arm Cortex-M (Nordic nrf52838) Microcontroller Wearable smart sensor electronics has the potential to revolutionize the medical field. Various body conformal flexible sensors have been used to monitor motion and physiological electrical signals such as electrocardiography (ECG), electroencephalography (EEG) and body composition analysis via body bio-impedance measurements. Smart sensor nodes not only provide accurate and continuous data in time but also automate the process of maintaining medical records, thereby lowering the workload of the health worker or clinician. This course offers an avenue for the students to understand the interdisciplinary principles that make it possible to interpret human physiology by utilizing discreet electronic components. Most importantly, participants will get a chance to do hands-on system design specific to electronically tracking a particular physiological phenomenon. In particular, the focus will be laid on programming of micro controllers, interfacing with sensors, acquisition of data and utilizing discreet analog elements for bio-signal processing. The programming will be performed in C.

The course will be taught in English and by the ITET center for project based learning.

**Projects & Seminars: Android Application Development (AAD)**

*Does not take place this semester.*

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective


Although the App-Industry is dominated by the giant Apps right now, it is still crucial that one knows how those Apps function and how those Apps are communicating with their hardware. This course offers the opportunity for the participants to understand the development of application using Android Studio. Most importantly, participants will get a chance to do hands-on software design specific to Android smartphone and the data acquisition from sensors, GPS, google maps and other internal devices. The main goal of the course if providing the students with the basic principle and software programming for building up every android application. The course include 4-5 weeks project were the students alone or in group will build up a working demo of a target application. The course will conclude with the presentation of the students work. Previous experience in C/Java or other languages is preferable but not mandatory. The students will program their own Android Smartphone.

The course will be taught in English by the new Project-based learning centre.

**Projects & Seminars: iCEBreaker FPGA For IoT Sensing Systems**

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
Objective

Deep neural networks (DNNs) have become the leading method for a wide range of data analytics tasks, after a series of major victories at the ImageNet Large Scale Visual Recognition Challenge (ILSVRC). For ILSVRC, the task was to classify images into 1000 different classes, many of which are difficult to distinguish (e.g. many classes are different breeds of dogs). All that was given were 1.2 million labelled images. Meanwhile, this recipe for success has taken over many more areas, from image-based tasks like segmenting objects in images, detecting objects, enhancing images using super-resolution and compression artifact reduction, to robotics and reinforcement learning, and a wide range of industrial applications.

DNNs and their subtype convolutional neural networks (CNNs) have not been new in the 2013 when the wave of success has started, but they got this huge boost through the new availability of large-scale dataset and—at least as importantly—the availability of the necessary compute resources by using GPUs to perform the computations required during training. While GPUs were then also used to stem the high computation effort of DNNs during inference (e.g. classifying images directly using a trained DNN rather than training the DNN itself). The high demand, the need for cost efficiency, and the goal of deploying DNNs not just in data centers but pervasively in everyday devices, wearables, and low-latency industrial or interactive applications, has triggered the development of various application-specific processors which are much faster, vastly more energy efficient, and cheaper at the same time—such as the Google TPU, Graphcore, ..., and Huawei’s Ascend/Atlas platforms.

In this course, you will learn:
1) the basics of deep neural networks, how they work, and what challenges there are for inference,
2) how platforms with specialized hardware accelerators, specifically the Huawei Atlas 200, can be used for running DNN inference and getting a practical application running, and
3) work on your own project using DNNs and hardware accelerators based on your own ideas or on some of our proposals.

Projects & Seminars: Embedded Deep Learning with Huawei Atlas 200 AI Dev Kit

The course will be taught in English by the new D-ITET center for Project-based Learning.

Projects authored and implemented in the framework of the course are an important part of the learning experience. They can be assigned to the students as group projects or as individual projects. The projects will be conducted in teams of 3-5 students and will be evaluated based on the quality of the implementation and the presentation of the project. The projects will be assigned at the beginning of the course and are expected to be completed within the last 5 weeks of the semester. The projects will be presented at the final project presentation, which will be held at the end of the semester.

Computer Vision beschäftigt sich unter anderem damit, Maschinen zu befähigen ihre Umwelt zu sehen und das wahrgenommene Bild zu verstehen. In unserem Projekt soll ein System entwickelt werden, das Spielkarten erkennen kann und, einer guten Strategie folgend, erfolgreich Black-Jack spielen kann. Die Teilnehmer des Projektes werden kleine Teams bilden und gemeinsam mit einem Assistenten die Aufgabe erarbeiten und eine Implementierung erstellen. Am Ende des Semesters sollen die Programme im öffentlichen Wettstreit gegeneinander antreten!


Als Voraussetzungen sollte Interesse an Computer Vision mitgebracht werden und die Bereitschaft, sich in einem Team von Mitstudierenden einzubringen. Kenntnisse in C++ sind notwendig.

Der Kurs wird von Prof. Fisher Yu mitbegutachtet.

Projekte können auch expandiert werden durch Pmod Interface und wechselbare CPU modules, so dass die Studenten eigene Projekte implementieren können.
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Magnetic fields can be found everywhere but are rarely directly perceptible. This also leads to sometimes irrational fears, such as of electrosmog. The power supply with direct current, 16.67 Hz and 50 Hz alternating current is indispensable today. Wherever electricity flows, magnetic fields are generated. That is why magnetic fields are omnipresent. But where do particularly high fields occur? How high can these fields be before they cause damage to health? Many studies have already dealt with this question and country-specific guidelines have been defined on this basis. But are these actually adhered to? Where are the legal limits exceeded? What are the consequences? The P&S will deal with this topic and an invited guest will speak.

At the end of the P&S, the individual groups present the findings

227-0085-33L Projects & Seminars: Accelerating Genome Analysis with FPGAs, GPUs, and New Execution Paradigms

Abstract

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Objective

In this course, we will cover the basics of genome analysis to understand the computational steps of the entire pipeline and find the computational bottlenecks. Students will learn about the existing efforts for accelerating one or more of these steps and will have the chance to carry out a hands-on project to improve these efforts.

The course is conducted in English.

Content

A genome encodes a set of instructions for performing some functions within our cells. Analyzing our genomes helps, for example, to determine differences in these instructions (known as genetic variations) from human to human that may cause diseases or different traits. One benefit of knowing the genetic variations is better understanding and diagnosis of diseases and the development of efficient drugs.

Computers are widely used to perform genome analysis using dedicated algorithms and data structures. However, timely analysis of genomic data remains a daunting challenge, due to the complex algorithms and large datasets used for the analysis. Increasing the number of processing cores used for genome analysis decreases the overall analysis time, but significantly escalates the cost of building, maintaining, and cooling such a computing cluster, as well as the power/energy consumed by the cluster. This is a critical shortcoming with respect to both energy production and environmental friendliness. Cloud computing platforms can be used as an alternative to distribute the workload, but transferring the data between the clinic and the cloud poses new privacy and legal concerns.

Prerequisites / notice

- No prior knowledge in bioinformatics or genome analysis is required.
- Digital Design and Computer Architecture (or equivalent course)
- A good knowledge in C programming language is required.
- Experience in at least one of the following is highly desirable: FPGA implementation and GPU programming.
- Interest in making things efficient and solving problems

Lecture notes

See past course materials here: https://safari.ethz.ch/projects_and_seminars/doku.php?id=bioinformatics

Literature

Learning Materials

3. An example of how to accelerate genomic sequence matching by two orders of magnitude with the help of FPGAs or GPUs: https://arxiv.org/abs/1910.09020
5. An example of using a different computing paradigm for accelerating read mapping step and improving its energy consumption: https://arxiv.org/pdf/1708.04329

227-0085-34L Projects & Seminars: Exploration of Emerging Memory Systems

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

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Projects & Seminars: Exploration of Emerging Memory Systems

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.
DRAM is predominantly used to build the main memory systems of modern computing devices. Emerging memory technologies (RRAM, PCM, STT-MRAM, FeRAM) provide an exciting opportunity to replace or complement DRAM. Simulation-based experimental studies are key for understanding the complex interactions between DRAM, emerging memory technologies, and modern applications. Ramulator is an extensible main memory simulator providing cycle-accurate performance models for a variety of commercial DRAM standards (e.g., DDR3/4, LPDDR3/4, GDDR5, HBM), emerging memory technologies, and academic proposals. Ramulator has a modular design that enables easy integration of additional standards, technologies and mechanisms. Ramulator is written in C++11 and can be easily integrated to full-system simulators such as gem5.

In this P&S, you will design new memory and memory controller mechanisms for improving overall system performance, energy consumption, reliability, security, scalability and cost. You will extend Ramulator with these new designs and evaluate their performance, energy consumption, and reliability using modern applications. This will be the right P&S for you if you would like to learn about the state-of-the-art and future memory and memory controller designs and their interaction with modern applications.

This P&S will also enable you to hands-on simulate and understand the memory system behavior of modern workloads such as machine learning, graph analytics, genome analysis.

The course is conducted in English.

Course website: https://safari.ethz.ch/projects_and_seminars/doku.php?id=ramulator

See https://safari.ethz.ch/projects_and_seminars/doku.php?id=ramulator

An old version of Ramulator:
https://github.com/CMU-SAFARI/ramulator

Original Ramulator paper:

An example study of modern workloads and DRAM architectures using Ramulator:

An example recent study of a new DRAM architecture using Ramulator:

An example recent study of a new virtual memory system architecture using Ramulator:

Several examples of new ideas enabled by Ramulator based evaluation
https://people.inf.ethz.ch/omutlu/pub/DR_STRANGE_EndtoEnd-DRAM-TRNG_hpcas2.pdf

In this P&S, you will design new memory and memory controller mechanisms for improving overall system performance, energy consumption, reliability, and security of DRAM. It is critical to perform experimental characterization and analysis of existing cutting-edge DRAM chips. SoftMC is an FPGA-based DRAM testing infrastructure that enables the programmer to perform all low-level DRAM operations (i.e., DDR commands) in a cycle-accurate manner. SoftMC provides a simple and intuitive high-level programming interface (in C++) that completely hides the low-level details of the FPGA from programmers. Programmers implement test routines in C++, and the test routines automatically get translated into the low-level SoftMC memory controller operations in the FPGA. SoftMC developers write low-level hardware description language code to enable new and faster studies.

In this P&S, you will have the chance to learn how DRAM is organized and operates in a low-level and gain practical experience in using SoftMC while developing SoftMC programs for new DRAM characterization studies related to performance, reliability, and security. You may also improve the SoftMC infrastructure itself to enable new studies. And, who knows, you might discover new security vulnerabilities like RowHammer.

This will be the right P&S for you if you are interested in DRAM technology and would like to learn more about it as well as FPGA technology and how it can be used for practical purposes such as understanding and mitigating RowHammer attacks, generating true random numbers, reducing memory latency, fingerprinting and identifying devices, and improving reliability.

The course is conducted in English.

See: https://safari.ethz.ch/projects_and_seminars/doku.php?id=softmc
Learning Materials:

- An old version of SoftMC is here: https://github.com/CMU-SAFARI/SoftMC
- SoftMC lecture: https://www.youtube.com/watch?v=-InSPEP3t-Ys

Prerequisites / notice

Prerequisites of the course:
- Digital Design and Computer Architecture (or equivalent course)
- Familiarity with FPGA programming
- Interest in low-level system exploration and memory
- Interest in discovering why things do or do not work and solving problems

227-0085-36L Projects & Seminars: Genome Sequencing on Mobile Devices

W 3 credits 3P M. H. K. Alser, J. Gómez Luna

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Genome analysis is the foundation of many scientific and medical discoveries, and serves as a key enabler of personalized medicine. This analysis is currently limited by the inability of existing technologies to read an organism’s complete genome. Instead, a dedicated machine (called sequencer) extracts a large number of shorter random fragments of an organism’s DNA sequence, known as reads. Small, handheld sequencers such as ONT MinION and Flongle make it possible to sequence bacterial and viral genomes in the field, thus facilitating disease outbreak analyses such as COVID-19, Ebola, and Zika. However, large, capable computers are still needed to perform genome assembly, which tries to reassemble read fragments back into an entire genome sequence. This limits the benefits of mobile sequencing and may pose problems in rapid diagnosis of infectious diseases, tracking outbreaks, and near-patient testing. The problem is exacerbated in developing countries and during crises where access to the internet network, cloud services, or data centers is even more limited.

In this course, we will cover the basics of genome analysis to understand the speed-accuracy tradeoff in using computationally-lightweight heuristics versus accurate computationally-expensive algorithms. Such heuristic algorithms typically operate on a smaller dataset that can fit in the memory of today’s mobile device. Students will experimentally evaluate different heuristic algorithms and observe their effect on the end results. This evaluation will give the students the chance to carry out a hands-on project to implement one or more of these heuristic algorithms in their smartphones and help the society by enabling on-site analysis of genomic data.

The course is conducted in English.

Prerequisites of the course:

227-0085-37L Projects & Seminars: Data-Centric Architectures

W 3 credits 3P J. Gómez Luna

Only for Electrical Engineering and Information Technology BSc.

The course unit can only be taken once. Repeated enrollment in a later semester is not creditable.

Abstract

The category of “Laboratory Courses, Projects, Seminars” includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Learning Materials:

3. An example of how to accelerate genomic sequence matching by two orders of magnitude with the help of FPGAs or GPUs: https://arxiv.org/abs/1910.09020
5. An example of using a different computing paradigm for accelerating read mapping step and improving its energy consumption: https://arxiv.org/pdf/1708.04329
7. An example of a purely software method for fast genome sequence analysis: http://www.biomedcentral.com/content/pdf/1471-2164-14-S1-S13.pdf

Prerequisites of the course:
- No prior knowledge in bioinformatics or genome analysis is required.
- A good knowledge in C programming language and programming is required.
- Interest in making things efficient and solving problems
Objective

Data movement between the memory units and the compute units of current computing systems is a major performance and energy bottleneck. From large-scale servers to mobile devices, data movement costs dominate computation costs in terms of both performance and energy consumption. For example, data movement between the main memory and the processing cores accounts for 62% of the total system energy in consumer applications. As a result, the data movement bottleneck is a huge burden that greatly limits the energy efficiency and performance of modern computing systems. This phenomenon is an undesired effect of the dichotomy between memory and the processor, which leads to the data movement bottleneck.

Many modern and important workloads such as machine learning, computational biology, graph processing, databases, video analytics, and real-time data analytics suffer greatly from the data movement bottleneck. These workloads are exemplified by irregular memory accesses, relatively low data reuse, low cache line utilization, low arithmetic intensity (i.e., ratio of operations per accessed byte), and large datasets that greatly exceed the main memory size. The computation in these workloads cannot usually compensate for the data movement costs. In order to alleviate this data movement bottleneck, we need a paradigm shift from the traditional processor-centric design, where all computation takes place in the compute units, to a more data-centric design where processing elements are placed closer to or inside where the data resides. This paradigm of computing is known as Processing-in-Memory (PIM).

This is your perfect P&S if you want to become familiar with the main PIM technologies, which represent "the next big thing" in Computer Architecture. You will work hands-on with the first real-world PIM architecture, will explore different PIM architecture designs for important workloads, and will develop tools to enable research of future PIM systems. Projects in this course span software and hardware as well as the software/hardware interface. You can potentially work on developing and optimizing new workloads for the first real-world PIM hardware or explore new PIM designs in simulators, or do something else that can forward our understanding of the PIM paradigm.

The course is conducted in English.

The course has two main parts:

Weekly lectures on processing-in-memory.
Hands-on project: Each student develops his/her own project.

Course website: https://safari.ethz.ch/projects_and_seminars/

Lecture notes

See: https://safari.ethz.ch/projects_and_seminars/

Literature

Learning materials

-------------

Summary papers about recent research in PIM.
https://people.inf.ethz.ch/omutlu/pub/ProcessingDataWhereItMakesSense_micpro19-invited.pdf

PIM Simulators.
Ramulator-PIM: A version of Ramulator simulator for PIM.
https://github.com/CMU-SAFARI/ramulator-pim
DAMOV simulator.
https://github.com/CMU-SAFARI/DAMOV

UPMEM SDK documentation: The first real-world PIM architecture.
https://sdk.upmem.com/2021.3.0/

An example recent study of 3D-stacked PIM for consumer workloads.

An example recent study of lightweight PIM functionality on 3D-stacked memory:

An example recent study of a PIM accelerator for graph processing.
https://people.inf.ethz.ch/omutlu/pub/tesseract-pim-architecture-for-graph-processing_isca15.pdf

An example recent study of a Processing-using-Memory system.

Prerequisites / notice

Prerequisites of the course:
- Digital Design and Computer Architecture (or equivalent course).
- Familiarity with C/C++ programming.
- Interest in future computer architectures and computing paradigms.
- Interest in discovering why things do or do not work and solving problems
- Interest in making systems efficient and usable

227-0085-38L Projects & Seminars: Controlling Biological Neuronal Networks Using Machine Learning W 3 credits 2P J. Vörös

Networks Using Machine Learning

Does not take place this semester.

Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these courses encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
The way memory and learning is achieved in the brain is an unsolved problem. Due to its relative simplicity, in-vitro neuroscience can help us discover the fundamentals of information processing in the brain. For this we can simulate a small number of biological neurons on top of an array of microelectrodes. Such an approach allows us to simulate the electrical activity of the neurons when they get stimulated.

Following this approach, we can investigate biological neural networks, that have about 5-50 neurons and a controlled network architecture. Still, their behavior remains highly unpredictable. Therefore, it is not yet clear how such networks need to be stimulated electrically in order to control their behavior. However, we can use machine learning to find a mapping between a stimulus and a desired response. More specifically, we can use reinforcement learning, since finding the right stimulation pattern is an instance of the so called multi-armed bandit problem.

This P&S consists of two parts. In the first part we will introduce you to the way neurons can be simulated. You will learn how neurons work and how they communicate. The second part will be about machine learning. We will discuss the basics of both artificial neural networks (ANN) and reinforcement learning. As homework exercises you will implement a reward function for a provided reinforcement learner, which will control your biological networks. In addition you will implement an ANN, that replaces unsatisfactorily performing stimulation patterns with new patterns, that this network evaluates to perform better.

If the current situation will allow, the developed ANNs will be tested on real neurons in our laboratory.

This P&S will be given in English. In total, the P&S takes 8 afternoons and about 50 hours of homework (ANN implementation).

### 227-0085-39L

**Projects & Seminars: Python for Science & Machine Learning**

*W* 3 credits 3P

**Course**

Does not take place this semester.

Only for Electrical Engineering and Information Technology BSc.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**

This beginner course to programming with Python - with a focus on applications in science and technology - is an ideal starting point for later courses. We will start with an introduction to the dev environment and tools for effective development to get you started. Then we will learn the basics of Python with exercises, and discover popular modules for data processing and visualisation that will be useful for your later studies and career. We conclude with an introduction to popular machine learning techniques and some time for you to implement your own small free-style projects.

By the end of the semester, you will

- be familiar with your PC's command-line interface and know how to use available dev environments effectively.
- have learned the basics of Python and be able to write basic programs that do what you want (most of the time) with the help of modules.
- be able to process, visualize and analyze numerical data, e.g. lab measurements, images, etc.
- have first experience with machine learning techniques
- maintain your first git repository and know how to collaborate with others on coding projects.

Language: English / German (if necessary)

### 227-0085-41L

**Projects & Seminars: Memory Design: From Architecture Down to Basic Cells**

Does not take place this semester.

Only for Electrical Engineering and Information Technology BSc.

**Course**

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

**Abstract**

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**

What is the cache memory and how much of it does a PC need? What is the difference between DRAM and SRAM? What are bit lines, word lines, column decoders and sense amplifiers? What does precharging mean and where is it used? How does a memory cell look on silicon and how is it manufactured? You will learn these and many other things in this P&S.

Memories are important components in all modern electronic devices (e.g. computer, smartphone, TV, ...). Depending on the area of application, an engineer can look at the storage system from different perspectives. This P&S gives an overview of these different perspectives and explains the relationships between them. Since these different perspectives are not only available for memory but for all integrated circuits in general, this P&S will help you to classify further specialized knowledge in a broader context. During the exercise part of the seminar, you will work with various simulation programs. These include sophisticated programs used by engineers in research and development. So you are going to practice on professional software, and during the simulations (exercise part) and group work / lectures (seminar part) you are going to develop basic knowledge that you can later deepen during the specialized lectures.

According to the different perspectives, the P&S "Basic Memory Design" consists of three parts of roughly the same length:

- **System Design:** In this part you are going to learn the various current storage types from the system developer point of view. What can you achieve? How are they built into circuits in order to obtain a storage system that offers the right size and speed with acceptable energy consumption? Since there are many different types of storage, the participants will study data sheets individually and will discuss them with the P&S assistants as part of a lecture (seminar part). With a simple cache simulator you will examine the influence of the design parameters in a memory hierarchy.

- **Circuit Design:** In this part you are going to learn the memory as an electronic circuit. How the transistors have to be interconnected in order to be able to write, save and read out data? How should these transistors be dimensioned in order to achieve the desired speed or energy efficiency? With simulations you will experience how the engineer examines and optimizes such circuits.

- **Physical Design:** This part goes even deeper. Millions of transistors on a small silicon wafer form a modern memory chip. How are the memory cells produced on the chip? What does a memory cell look like? How is the memory cell optimized? With the help of modern simulation tools, you will get to know the design practices that are used during development today. You will also learn about the methods and technologies used to manufacture modern integrated circuits.
Fostered competencies

### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

### Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

### Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Projects & Seminars: Understanding and Designing Modern SSDs (Solid-State Drives)

#### 227-0085-44L
**W** 3 credits  **SP**

**S. Sadrosadati**

**Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.**

**Abstract**
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

**Objective**
NAND flash memory is the de facto standard for architecting a storage device in modern computing systems. As modern computing systems process a large amount of data at an unprecedented scale, a storage device needs to meet high requirements on storage capacity and I/O performance. A NAND flash-based solid-state drive (SSD) can provide orders-of-magnitude higher I/O performance compared to traditional hard-disk drives (HDDs), with a much lower cost-per-bit value over SSDs based on emerging non-volatile memory (NVM) technologies.

NAND flash memory has several unique characteristics, such as the erase-before write property (i.e., a flash cell needs to be first erased before programming it), limited lifetime (i.e., a cell cannot reliably store data after experiencing a certain number of program/erase (P/E) cycles), and large operation units (e.g., modern NAND flash memory typically reads/writes data in a page (e.g., 16 KiB) granularity). To achieve high performance and large capacity of the storage system while hiding the unique characteristics of NAND flash memory, it is critical to design efficient SSD firmware, commonly called Flash-Translation Layer (FTL). An FTL is responsible for many critical management tasks, such as address translation, garbage collection, wear leveling, and I/O scheduling, which significantly affect the performance, reliability, and lifetime of the SSD.

In this course, we will cover how a modern NAND flash-based SSD is organized and operates, from the basics of underlying NAND flash devices and various SSD-management tasks at the FTL level. We will also examine other emerging memory technologies for building SSDs, such as Phase Change Memory, 3D XPoint (e.g., Intel Optane SSD) and more.

You will help build a practical SSD simulator by refactoring MQSim, a state-of-the-art simulator for high-end SSDs, to support advanced features of modern NAND flash chips and essential SSD-management tasks. This will allow you to have the chance to obtain a comprehensive background in modern storage systems and research experience on system optimization with rigorous evaluation.

The course is conducted in English.

The course has two main parts:
- Weekly lectures on modern NAND flash-based SSDs
- Hands-on project to refactor MQSim

**Course website:** https://safari.ethz.ch/projects_and_seminars/

**Lecture notes**
See: https://safari.ethz.ch/projects_and_seminars/
**Literature**

- Inside NAND Flash Memories: https://search.library.ethz.ch/permalink/t/823s1o/ELENDING603606
- Inside Solid State Drives (SSDs): https://search.library.ethz.ch/permalink/t/823s1o/ELENDING1030264
- MQSim, an open-source multi-queue SSD simulator
- Source code: https://github.com/CMU-SAIFR/MQSim

**Prerequisites**

- **Projects & Seminars: Machine Learning on Smart Phone**
  - Does not take place this semester.
  - Only for Electrical Engineering and Information Technology BSc.

  **Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.**

  **Abstract**

  The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

  **Objective**


  Drones can be fun to use but understanding the hardware and software and building and programming them to be intelligent and autonomous is even better. This course gives the basis of the embedded systems having the drones as the primary target. The course will introduce embedded systems and, in particular, the microcontroller ARM Cortex-M, focusing on all the crucial blocks such as Interrupts, GPIO, ADC's, Timers, and Serial communication protocols. Apart from the core topics, real-time and power-efficient algorithms for attitude and motor control are also discussed, making the drone efficient. Finally, exciting drone exercises are supported in the course to experiment with the development kit. The course will end with a 4-5 weeks project where the students will make the drone fly with some specific goal. It is not required any previous knowledge except C language.

  The course will be taught in English and organized by the new Project-Based Learning center.

**Registering in Semester**

- Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

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The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Abstract

Machine Learning with Smart Phone Sensors – Programming Android Phones – Neural Networks – Keras/Tensor Flow – Projects and App on smartphones

Smartphones have several sensors that can acquire much useful information, for instance where we are, what we are doing, with whom we are together, what is our constitution, what are our needs. Based on this information our 'smartphone' offers us the appropriate computational power to process them in loco without sending the sensor data to the cloud. This course focus on giving the bases of machine learning and embedded systems. The student will learn the tools to implement a machine learning algorithm, such as Tensor Flow and others in their android phones to have an advanced smartphone. The course will end with 4 weeks project where the students can target a specific application scenario. It is not required any previous experience in machine learning. Phyton is a plus but the basis of phyton will be given in the course to be able to complete the project.

The course will be taught in New English and organized by the new Project-based Learning center.

227-0085-48L Projects & Seminars: Introduction to Program Nao Robots for Robocup Competition

Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective


NAO robots from Softbank are the leading humanoid robot being used in research and education worldwide. Robotics is the fastest growing and most advanced technology used in education and research. The main goal of this course is to introduce and allowing the students to learn how to program an NAO humanoid robot to make him walk, talking, watching objects understanding the human, and reacting to external input. The Nao Robots used in this course are equipped with many sensors: Tactile Sensors, Ultrasonic sensors, A Gyro, An Accelerometer, Force Sensors, Infrared sensors, 2 HD Cameras, 4 Microphones, and high accuracy digital encoders on each joint. It has two processors on board: an Intel Atom 1.6Ghz (The main computer includes SSD drive, WiFi, Bluetooth, and wired network) and an additional ARM-9 processor in its chest.

The course will introduce the software package and the full SDK and API. The students will learn how to program ( mainly in C and Phyton) the robot to access the full functionality. To improve the hands-on skills of students the course will end with a 5 weeks project where the students in the group will compete in a small soccer game where the robots will play the game following and kicking a red ball. It is not requested any previous knowledge but programming skills are a plus.

The course will be taught in English and organized by the new Project-based Learning center.

227-0085-49L Projects & Seminars: Smart Patch Projects

Does not take place this semester.

Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Wearable devices, PCB Design, Firmware developing, multi-sensors, Communication.

The Smart Patch project will design autonomous, low power and mesh enabled multi-sensor wearable smart patches. They will be based on the always-on smart sensing paradigm to continuously acquire process and stream physiological data in real-time. They can be trained to autonomously detect illness symptoms or other physical conditions, such as stress. The students will work in a team to design a sub-block of the smart patch. According to the students' background, they will be associated with designing the hardware or the firmware. Together in a team, they will learn how to structure problems and identify solutions, system analysis, and simulation, as well as presentation and documentation techniques. They will get access to D-ITET labs and state-of-the-art engineering tools (Matlab, Simulink, Firmware development IDE, PCB Design, etc.)

The projects will be done under the Smart Patches: a flagship project for D-ITET students. (pbl.ee.ethz.ch)

227-0085-51L Projects & Seminars: Programming Heterogeneous Computing Systems with GPUs and other Accelerators

Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.
The increasing difficulty of scaling the performance and efficiency of CPUs every year has created the need for turning computers into heterogeneous systems, i.e., systems composed of multiple types of processors that can suit better different types of workloads or parts of them. More than a decade ago, Graphics Processing Units (GPUs) became general-purpose parallel processors, in order to make their outstanding processing capabilities available to many workloads beyond graphics. GPUs have been a critical key to the recent rise of Machine Learning and Artificial Intelligence, which took unrealistic training times before the use of GPUs. Field-Programmable Gate Arrays (FPGAs) are another example computing device that can deliver impressive benefits in terms of performance and energy efficiency. More specific examples are (1) a plethora of specialized accelerators (e.g., Tensor Processing Units for neural networks), and (2) near-data processing architectures (i.e., placing compute capabilities near or inside memory/storage).

Despite the great advances in the adoption of heterogeneous systems in recent years, there are still many challenges to tackle, for example:

- Heterogeneous implementations (using GPUs, FPGAs, TPUs) of modern applications from important fields such as bioinformatics, machine learning, graph processing, medical imaging, personalized medicine, robotics, virtual reality, etc.
- Scheduling techniques for heterogeneous systems with different general-purpose processors and accelerators, e.g., kernel offloading, memory scheduling, etc.
- Workload characterization and programming tools that enable easier and more efficient use of heterogeneous systems.

If you are enthusiastic about working hands-on with different software, hardware, and architecture projects for heterogeneous systems, this is your P&S. You will have the opportunity to program heterogeneous systems with different types of devices (GPUs, CPUs, FPGAs, TPUs), propose algorithmic changes to important applications to better leverage the compute power of heterogeneous systems, understand different workloads and identify the most suitable device for their execution, design optimized scheduling techniques, etc. In general, the goal will be to reach the highest performance reported for a given important application.

The course is conducted in English.

The course has two main parts:
Weekly lectures on GPU and heterogeneous programming.
Hands-on project: Each student develops his/her own project.

Course website: https://safari.ethz.ch/projects_and_seminars/doku.php?id=heterogeneous_systems


See: https://safari.ethz.ch/projects_and_seminars/doku.php?id=heterogeneous_systems

227-0085-53L

Projects & Seminars: Motion Sensing Technologies

W 4 credits 4P K. P. Prüssmann

for Magnetic Resonance Imaging (MRI)

Does not take place this semester.

Only for Electrical Engineering and Information Technology BSc.

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract

The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective

Content

Lecture notes

Literature

Prerequisites / notice

1. An introduction to SIMD processors and GPUs:
http://www.youtube.com/watch?v=hOlIkAYrата

2. An introduction to GPUs and heterogeneous programming: http://www.youtube.com/watch?v=y40-y5WJ8A

3. Example recent studies of FPGA and GPU implementation for bioinformatics:
SneakySnake: Pre-alignment filter on FPGA and GPU (Bioinformatics 2020):

4. An example recent study of a suite of heterogeneous benchmarks:

5. An example recent study of a medical image application on GPU:

6. Example studies of programming tools and performance portability on heterogeneous systems:
Locality descriptor: Cross-layer abstraction to express data locality on GPUs (ISCA 2018):

7. Example studies of scheduling techniques for heterogeneous systems:

1. An introduction to SIMD processors and GPUs:

2. An introduction to GPUs and heterogeneous programming: http://www.youtube.com/watch?v=y40-y5WJ8A

3. Example recent studies of FPGA and GPU implementation for bioinformatics:

4. An example recent study of a suite of heterogeneous benchmarks:

5. An example recent study of a medical image application on GPU:

6. Example studies of programming tools and performance portability on heterogeneous systems:

7. Example studies of scheduling techniques for heterogeneous systems:
Current MRI scans are limited by patient motion. In clinics, radiologists are often confronted with images with severe motion artefacts in their images. They either have to make a diagnosis although the image artefacts were they could miss crucial information, or they have to send the patient back into the scanner for reacquisition. Such reacquisition might inflict additional costs in the six-figure range per scanner per year.

Further, in research, MRI images from ultra-high field systems are already limited by motion from the cardio-biostatic and respiratory movement. Resulting in subpar performance if not addressed appropriately.

The key to overcoming such motion artefacts is estimating the motion and correct for it. Preferably this is done prospective in real-time or otherwise afterwards retrospective in the image reconstruction. Such methods are instrumental in brain imaging since the brain's movement is well described by the rigid body behaviour of the skull.

To do such motion correction, one needs a motion-sensing technology to measure the movement of the human skull with high precision, accuracy and temporal resolution. All this has to be done while being integrated into an MRI machine where powerful static magnetic fields are present, kW of pulsed RF power and MVA of changing magnetic field gradients are present.

In this P&S we explore different motion sensing technologies suitable for deployment in an MRI machine. What you can expect is that we discuss the theory of multiple sensing technologies and then implement an optical, shortwave RF and NMR phase motion sensor. We will spend most of our time in the lab constructing such sensors and testing them on our robotic test bench. Finally, we would also experiment in our MRI facilities, where we would perform motion correction experiments.
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and continuous monitoring of physiological parameters, and many companies and research centers are actively working on the development of the next generation of truly-wearable ultrasound for a number of monitoring and diagnostics applications. To sustain such recent developments, it is important to be familiar with all sub-components (hardware and software) of such biomedical systems.

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The course will be taught in English.

Ultrasound is one of the most used medical imaging techniques and it enables many applications, including the monitoring of musculoskeletal activity during movement, the imaging of carotid artery, and the control of prosthetic devices for human-machine interfaces. Recent developments showcased wearable ultrasound probes operating at minimal power consumption, enabling multi-day continuous monitoring of physiological parameters, and many companies and research centers are actively working on the development of the next generation of truly-wearable ultrasound for a number of monitoring and diagnostics applications. To sustain such recent developments, it is important to be familiar with all sub-components (hardware and software) of such biomedical systems.

The course will be taught in English.

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Objective
Autonomous mobile robotics is a promising field that spans from food delivery robots to the Perseverance Mars rover. In this P&S you will be introduced to the fundamental building blocks of robotics, by hands on experience in the context of the F1TENTH autonomous racing and the Robot Operating System (ROS)!

Autonomous racing pushes the boundaries in algorithmic design and implementation in the fields of perception, planning and control. Thus it serves researchers as a limits test for autonomous driving and is an important building step in the field of general self driving and AI. F1TENTH is an open-source autonomous racing competition involving a racing car in the scale of 1:10.

This P&S allows you to apply hands-on robotics and is the right fit for you if you want to further delve into this fascinating field of embedded systems, perception, planning and control. Lastly, you will get experience in the widely used ROS framework.

Prerequisites / notice
- Can use the Linux-Terminal (e.g. navigating folder structure and ssh)
- Python (e.g. basic loops, OOP)
- Interest in autonomous driving
- 20GB of free space on your laptop

Course can only be registered for once. A repeatedly registration in a later semester is not chargeable.

Abstract
The category of "Laboratory Courses, Projects, Seminars" includes courses and laboratories in various formats designed to impart practical knowledge and skills. Moreover, these classes encourage independent experimentation and design, allow for explorative learning and teach the methodology of project work.

Objective
The objective of this P&S is to expose students to both common and cutting-edge neural architectures and to build intuition about their inner working by the means of examples. Students learn about various network structures as building blocks and use them to solve worked examples and course challenges. After attending this course, students will be familiar with multi-layer perceptrons, convolutional neural networks, recurrent neural networks, transformer encoders, graph convolutional/isomorphism/attention networks, and autoencoders.

Content
This P&S introduces deep learning through the PyTorch framework in a series of hands-on examples, exploring topics in computer vision, natural language processing, graph neural networks, and representation learning.

Lecture notes
Python Notebooks will be distributed to students before every session.

Group Projects

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<td>227-0091-10L</td>
<td>Group Project I ■</td>
<td>W</td>
<td>6</td>
<td>5A</td>
<td>Lecturers</td>
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<tr>
<td>Abstract</td>
<td>Students must work in groups in supervised projects for 150 to 180 hours minimum. The topics of the group work are open and can be technical of specific nature or more general in the context of engineering.</td>
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<td>Objective</td>
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| 227-0092-10L | Group Project II ■                 | W    | 6    | 5A    | Lecturers |
| Abstract | Students must work in groups in supervised projects for 150 to 180 hours minimum. The topics of the group work are open and can be technical of specific nature or more general in the context of engineering. |
| Objective | see above |

Internship in Industry

The internship in industry can only be enrolled for during bachelor's studies according to the 2016 regulations. According to the 2018 regulations, an internship in industry can be taken at master's level.

Please note the conditions for internships in industry as set forward by the "Guidelines for the "Laboratory Courses - Projects - Seminars ", see https://www.ee.ethz.ch/content/dam/ethz/special-interest/let/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_v5_final.pdf (German only).

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<td>W</td>
<td>6</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Only for students in the Bachelor's Programme Electrical Engineering and Information Technology, Regulations 2016. For students enrolled in the 2018 Programme Regulations, see &quot;227-1550-10L Internship in Industry&quot; at Master's level.</td>
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<tr>
<td>Objective</td>
<td>The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
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</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 895 of 2416
Please note the conditions for Internships in industry as set forward by the "Guidelines for the "Laboratory Courses - Projects - Seminars "; see https://ethz.ch/content/dam/ethz/special-interest/itet/department/Studies/Bachelor/Regulations/Richtlinien_Praktika-Projekte-Seminare_v5_final.pdf (German only).

### 5th Semester: Third Year Core Courses

**Can be freely combined, a list of recommendations is available under https://ee.ethz.ch/studies/bachelor/third-year/core-courses.html**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

**Abstract**

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

**Objective**

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

---

**5th Semester: Third Year Core Courses**
Content

1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

227-0102-00L Discrete Event Systems W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content

1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Literature

[bertsekas]  Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin]  Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv
Cambridge University Press, 1998

[boudec]  Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras]  Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune

[fiat]  Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[schickinger]  Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser]  Introduction to the Theory of Computation
Michael Sipser

227-0103-00L Control Systems W 6 credits 2V+2U F. Dörfler

Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Concepts and Theories

VLSI 1: HDL Based Design for FPGAs

Power Electronics

<table>
<thead>
<tr>
<th>Literature</th>
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</thead>
</table>

Prerequisites / notice

Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

<table>
<thead>
<tr>
<th>227-0113-00L</th>
<th>Power Electronics</th>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>J. W. Kolar</th>
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<tr>
<td>Objective</td>
<td>Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.</td>
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<tr>
<td>Content</td>
<td>Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous conduction mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DCDC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.</td>
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<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
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<td>Method-specific Competencies</td>
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<td></td>
<td>Concepts and Theories</td>
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<td></td>
<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
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VLSI 1: HDL Based Design for FPGAs

6 credits

| Abstract | This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits. | 
| Objective | Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools. | 

F. K. Gürkaynak, L. Benini

Autumn Semester 2022

Page 898 of 2416
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anequi diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

**Lecture Slides**
**Embedded Systems**

**4G**

**Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet**


**Examination:**
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://pbl.ee.ethz.ch/education/embedded-systems.html
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Prerequisites: Basic knowledge in computer architectures and programming.

Prerequisites

Solid State Electronics and Optics

Objectives

Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials.

Recommended background:

Undergraduate physics, mathematics, semiconductor devices

Literature


Qubits, Electrons, Photons

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!


Supplementary material will be uploaded in Moodle.

- (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer
- (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
227-0385-10L  Biomedical Imaging

Abstract
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Objective
Upon completion of the course students are able to:
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Content
- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PECT)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

Lecture notes
Lecture notes and handouts

Literature
Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011
Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

227-0393-10L  Bioelectronics and Biosensors

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field
1. Introduction

Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
14. Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Objective
Computation is everywhere, but what is computation actually? In this lecture we will discuss the power and limitations of computation. Computational thinking lies at the heart of many exciting scientific, social and even philosophical developments. Computational thinking is more than programming a computer, it means thinking in abstractions. Consequently, computational thinking has become a fundamental skill for everyone, not just computer scientists. For example, functions which can easily be computed but not inverted are at the heart of understanding data security and privacy. Machine learning on the other hand has given us fascinating new tools to teach machines how to estimate functions. Thanks to clever heuristics, machines now appear to be capable of solving complex cognitive tasks. To give just one more example: How can we design the best electronic circuit for a given problem? In this class, we study various problems together with the fundamental theory of computation.

The weekly lectures will be based on blackboard discussions and coding demos, supported by a script and coding examples. The course uses Python as a programming language. Python is popular and intuitive, a programming language that looks and feels a bit like human instructions. The lecture will feature weekly exercises, on paper and in Python.

High-Frequency Design Techniques

Abstract
Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Objective
Familiarize students with the essential tools and principles exploited in high-frequency design. Introduction to circuit simulation.
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business

ECTS 4G C. Franck, G. Hug

At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important

C. Franck

not assessed

Hours

3G

Introduction to wireless, radio spectrum, review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit
design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave
ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, antenna basics.

Lecture notes

Literature

access via ETH-Bibliothek)

227-0122-00L Introduction to Electric Power Transmission: System & Technology

Abstract

Introduction to theory and technology of electric power transmission systems.

Objective

At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important

components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of

transformers and lines, calculate stationary power flows and other basic parameters in simple power systems.

Content

Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems,
technology and principle of electric power systems.

Lecture notes

Lecture script in English, exercises and sample solutions.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Economics, Law and Management Electives

These subjects are particularly suitable for students planning to apply to the Master's Degree Program in Energy Science and Technology (MSc EST) or Management, Technology and Economics (MSc MTEC).

Data: 01.11.2022 12:41    Autumn Semester 2022    Page 903 of 2416

351-0778-00L Discovering Management

Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Exercise).

Abstract

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural

scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and

managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

Objective

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:

(1) broaden understanding of management principles and frameworks

(2) advance insights into the sources of corporate and entrepreneurial success

(3) develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the

challenges that entrepreneurs and managers deal with.

Content

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business

management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation

Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one

practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and

case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or

entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team

coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear

recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

These course materials will form the point of departure for the lectures, class discussions and team work.

Autumn Semester 2022
Discovering Management (Exercises) 351-0778-01L

Complementary exercises for the module Discovering Management.

Prerequisite: Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

Abstract

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

Objective

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Content

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Literature

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

Subject-specific Competencies

- Concepts and Theories

Method-specific Competencies

- Analytical Competencies
- Problem-solving

Social Competencies

- Communication
- Self-presentation and Social Influence

Personal Competencies

- Creative Thinking
- Critical Thinking

Managerial Economics 351-0511-00L

Not for MSc students belonging to D-MTEC!

"Managerial Economics" provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

Objective

The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Literature


Prequisites

The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

Introduction to Microeconomics 351-1109-00L

Not for MSc students belonging to D-MTEC!

This course is only for students enrolled in a Bachelor’s degree programme.

Students enrolled in a Master’s degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract

The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective

Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Content

Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes

Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature


Prerequisites

This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

A comprehensive script will be made available online on the moodle platform.
Objective
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice
The lecture addresses students in the fields of engineering, science and other related technical fields.

Fostered competencies
- Subject-specific Competencies
  - Concepts and Theories
  - assessed
- Method-specific Competencies
  - Problem-solving
  - assessed
- Personal Competencies
  - Critical Thinking
  - assessed
  - Self-awareness and Self-reflection
  - assessed

Content
You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions.

- Generic time-harmonic electromagnetic fields
- Fundamental solutions of the wave equation
- Wave propagation in various types of materials
- Interaction of waves with matter
- Nonlinear effects
- Resonant effects
- Applications like scattering, waveguiding, radiation
- Radio frequency and optical antennas

Lecture notes
Lecture notes and slides will be handed out during the lectures.

Prerequisites / notice
Lecture notes will be handed out as the course progresses.

Additional third year core courses may be credited as electives.

Number | Title | Type | ECTS | Hours | Lecturers |
--- | --- | --- | --- | --- | --- |
227-0105-00L | Introduction to Estimation and Machine Learning | W | 6 credits | 4G | H. A. Loeliger |
Abstract
Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

Objective
Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Content
Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more

Lecture notes
Lecture notes will be handed out as the course progresses.

Prerequisites / notice
- solid basics in linear algebra and probability theory
- Need for solid basics in probability theory

227-0110-00L | Electromagnetic Waves: Materials, Effects, and Antennas | W | 6 credits | 4G | U. Koch |
Abstract
This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.

Objective
You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions.

Content
The lecture covers the following topics:
- Generic time-harmonic electromagnetic fields
- Fundamental solutions of the wave equation
- Wave propagation in various types of materials
- Interaction of waves with matter
- Nonlinear effects
- Resonant effects
- Applications like scattering, waveguiding, radiation
- Radio frequency and optical antennas

Lecture notes
Lecture notes and slides will be handed out during the lectures.

Prerequisites / notice
Lecture notes will be handed out as the course progresses.

227-0517-10L | Fundamentals of Electric Machines | W | 6 credits | 4G | D. Bortis, R. Bosshard |
Abstract
This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

Objective
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

Content
- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machines, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes
Lecture notes and associated exercises including correct answers

227-0652-00L | Maxwell, Einstein, and the GPS | W | 6 credits | 2V+2U | T. Zambelli |
Abstract
The course introduces students to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.
Abstract
Maxwell’s equations are reinterpreted in the framework of Einstein’s special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

Objective
D-ITET is the depository of the Maxwell’s equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves.

Only one aspect is left over: the fact that they are not invariant with respect to the classical Galilean transformation… On the contrary, Maxwell’s equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell’s equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

Content
- Galileo-Newton, the Ether, Michelson-Morley’s Experiment
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac’s Effect
- GPS

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Sprachliche Übersetzung: Maxwell’s Equations are reinterpreted in the framework of Einstein’s Special Relativity using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

Ziel
D-ITET is the depository of Maxwell’s equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves.

Only one aspect is left over: the fact that they are not invariant with respect to the classical Galilean transformation… On the contrary, Maxwell’s equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell’s equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

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Inhaltsangabe
- Galileo-Newton, the Ether, Michelson-Morley’s Experiment
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac’s Effect
- GPS

Lecture notes
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!
Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

See https://safari.ethz.ch/architecture_seminar for past examples.

All the materials will be posted on the course website: https://safari.ethz.ch/architecture_seminar/

Links to past course materials, including the synthesis report assignment, can be found in this page: https://safari.ethz.ch/architecture_seminar

Key papers and articles, on both fundamentals and cutting-edge topics in computer architecture will be provided and discussed. These will be posted on the course website.

Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice.

The course also covers support for data cubes (analytics).

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices — you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality.
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Autumn Semester 2022
### Fostered competencies

<table>
<thead>
<tr>
<th>Type</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<td>not assessed</td>
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<tr>
<td>Techniques and Technologies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td>Problem-solving</td>
<td>assessed</td>
<td>not assessed</td>
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<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td>Negotiation</td>
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<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td>assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
<td>Negotiation</td>
<td>assessed</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed

### Social Competencies

- Communication: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

### Personal Competencies

- Creative Thinking: not assessed
- Critical Thinking: assessed

### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed

### Social Competencies

- Communication: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

### Personal Competencies

- Creative Thinking: not assessed
- Critical Thinking: assessed

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### Science in Perspective

#### Science in Perspective

**see Science in Perspective: Type A: Enhancement of Reflection Capability**

**Recommended Science in Perspective (Type B) for D-ITET**

### Language Courses

**see Science in Perspective: Language Courses ETH/UZH**

### Bachelor's Project

*The Bachelor's Thesis is the final part of the bachelor's program and should therefore only be taken in the semester in which the bachelor's diploma is*
The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B) and
- subjects of the second year (examination blocks 1-3)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0100-00L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>12</td>
<td>26D</td>
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</tbody>
</table>

A 14 week long Bachelor's Thesis is the final part of the bachelor's program and shall therefore be taken during the semester in which the bachelor's diploma is acquired.

The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B)
- subjects of the second year (examination blocks 1-3)

Supervisor must be a professor at D-ITET or associated, see a link to the lists of those at https://ee.ethz.ch/studies/bachelor/third-year/bachelor-project.html

Abstract
During the Bachelor's Thesis, students will gain initial experience in the independent solution of a technical-scientific problem by applying the acquired specialist and social skills.
A Bachelor's Thesis should take about half of a student's time during one semester, i.e., about 300-400 hours. The thesis includes an oral presentation and a written report, and it is graded.

Objective
see above

Prerequisites / notice
A 14 week long Bachelor's Thesis is the final part of the bachelor's program and shall therefore be taken during the semester in which the bachelor's diploma is acquired.

The minimum requirement for enrollment is the successful completion of:
- basic examination (examination blocks A+B)
- subjects of the second year (examination blocks 1-3)

Supervisor must be a professor at D-ITET or associated, see a link to the lists of those at https://ee.ethz.ch/studies/bachelor/third-year/bachelor-project.html

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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
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<td>U. Koch</td>
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</tbody>
</table>

Strongly recommended prerequisite for Semester Projects and Master Theses at D-ITET (MSc BME, MSc EEIT, MSc EST).

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Discussion of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, "in this paper" paragraph, scientific part, summary, equations, figures)
* Topic 2: Structure of Scientific Presentations
* Topic 3: Citation Rules and Citation Software
* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature
ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html
ETH "Scientific Integrity", see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html

Prerequisites / notice
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

Electrical Engineering and Information Technology Bachelor - Key for Type

| O    | Compulsory          | E-   | Recommended, not eligible for credits |
| W+   | Eligible for credits and recommended | Z    | Courses outside the curriculum |
| W    | Eligible for credits | Dr   | Suitable for doctorate |

Key for Hours

| V    | lecture             | P    | practical/laboratory course |
| G    | lecture with exercise| A    | independent project |
| U    | exercise             | D    | diploma thesis |
| S    | seminar              | R    | revision course / private study |
| K    | colloquium           |      |                             |

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
### Educational Science

#### General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<td>Human Learning (EW1)</td>
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<td>This lecture is only apt for students who intend to enrol in the programs &quot;Teaching Diploma&quot; or &quot;Teaching Certificate&quot;. It is about learning in childhood and adolescence.</td>
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<td>This course looks into scientific theories and also empirical studies on human learning and relates them to the school.</td>
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<td>Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.</td>
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<td>und Kompetenzerwerb unter besonderer Berücksichtigung des Wissens-</td>
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<td>transfersts; Lernen durch Instruktion und Erklärungen; Die Rolle von</td>
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<td>Lecture notes</td>
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<td></td>
<td>1) Marcus Hasselhorn &amp; Andreas Goid (2006): Pädagogische Psychologie:</td>
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<td></td>
<td>Professional Handlungswissen für Lehrerinnen und Lehrer. Kohlhammer</td>
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<td></td>
<td>This course is only apt for students who intend to enrol in the programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning in childhood and adolescence.</td>
<td></td>
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</tr>
</tbody>
</table>

| 851-0240-22L | Coping with Psychosocial Demands of Teaching (EW4 W/DZ) | W    | 2    | 3S    | U. Markwalder, S. Maurer, S. Peteranderl-Rüschoff |
|              | Number of participants limited to 20.                    |      |      |       |                                        |
|              | The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite. |      |      |       |                                        |
|              | Abstract                                                |      |      |       |                                        |
|              | In this class, students will learn concepts and skills for coping with psychosocial demands of teaching |      |      |       |                                        |
|              | Objective                                               |      |      |       |                                        |
|              | (1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks). |      |      |       |                                        |
|              | (2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services). |      |      |       |                                        |

| 851-0242-05L | Cognitively Activating Instructions in MINT Subjects | W    | 2    | 2S    | R. Schumacher                           |
|              | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |      |      |       |                                        |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)". |      |      |       |                                        |
|              | Abstract                                                |      |      |       |                                        |
|              | This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance. |      |      |       |                                        |
|              | Objective                                               |      |      |       |                                        |
|              | - Get to know cognitively activating instructions in MINT subjects |      |      |       |                                        |
|              | - Get information about recent literature on learning and instruction |      |      |       |                                        |
|              | Prerequisites / notice                                  |      |      |       |                                        |
|              | Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht. |      |      |       |                                        |

| 851-0242-07L | Human Intelligence                                      | W    | 1    | 1S    | E. Stern                               |
|              | Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport). |      |      |       |                                        |
|              | Number of participants limited to 30.                  |      |      |       |                                        |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)". |      |      |       |                                        |
|              | Abstract                                                |      |      |       |                                        |
|              | The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed. |      |      |       |                                        |
|              | Objective                                               |      |      |       |                                        |
|              | - Understanding of research methods used in the empirical human sciences |      |      |       |                                        |
|              | - Getting to know intelligence tests                    |      |      |       |                                        |
|              | - Understanding findings relevant for education         |      |      |       |                                        |
|              | Prerequisites / notice                                  |      |      |       |                                        |
|              |                                                        |      |      |       |                                        |
| 851-0242-08L | Research Methods in Educational Science                | W    | 1    | 2S    | C. M. Thurn, T. Braas, P. Edelsbrunner |
|              | Number of participants limited to 30.                  |      |      |       |                                        |
|              | This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human
Abstract

Learning (EW 1)”. Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective

- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-11L</td>
<td>Gender Issues In Education and STEM ■</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>M. Berkowitz Biran, T. Braas, C. M. Thurn</td>
</tr>
<tr>
<td>851-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School ■</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>U. Markwalder</td>
</tr>
</tbody>
</table>

Abstract

In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the underrepresentation of girls and women in technology, engineering and mathematics (STEM), Common perspectives, controversies and empirical evidence will be discussed.

Objective

- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher's work.

Content

Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice

Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).
the examination lessons are to be repeated.

**Abstract**
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

**Objective**
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

**Content**

**Prerequisites:** successful completion of FD I and FD II

**Objective**
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

**Content**
Gemäss aktueller Ablaufplanung mit Mentor und Betreuer.

Das Fachgebiet richtet sich nach dem aktuellen Unterrichtsprogramm des betreuenden FH/BMS-Dozenten, und seinem Auftrag zum geleiteten Selbststudium. Auszugehen ist vom verwendeten Skript / Lehrbuch Zu erarbeiten ist die dazugehörende eLearning-Umgebung (Tests, Repetitionsfragen, Uebungsaufgaben, Arbeitsprogramme, etc.).

Andernfalls ist eine einfach handhabbare, lizenzfreie Plattform in Absprache mit dem Betreuer festzulegen.


**Prerequisites / notice**
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

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**Electrical Engineering and Information Technology TC - Key for Type**

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 914 of 2416
Electrical Engineering and Information Technology Master

► Master Studies (Programme Regulations 2018)

►► Communication

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Communication", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

►►► Core Courses

These core courses are particularly recommended for the field of "Communication". You may choose core courses from other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

►►► Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0121-00L</td>
<td>Communication Systems</td>
<td></td>
<td>6 credits</td>
<td>4G</td>
<td>to be announced</td>
</tr>
</tbody>
</table>

Abstract

Does not take place this semester.

Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

Objective

Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

Content

Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

Lecture notes

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Literature


227-0101-00L | Discrete-Time and Statistical Signal Processing | W | 6 credits | 4G | H.-A. Loeliger |

Abstract

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content

1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

227-0301-00L | Optical Communication Fundamentals | W | 6 credits | 2V+1U+1P | J. Leuthold |

Abstract

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

Objective

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.
Content

* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.


* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

* Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes

Lecture notes are handed out.

Literature

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

Prerequisites / notice


227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth

Abstract

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Communication", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

Number Title Type ECTS Hours Lecturers
227-0102-00L Discrete Event Systems W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content

1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes

Available
This course is concerned with tailoring algorithms and with devising high-performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front-end design using HDLs and automatic synthesis for producing industrial-quality circuits.

### Content
- Overview of design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGA. Commercial EDA software by leading vendors is being used throughout.

### Literature
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Lecture notes are handed out.

Further details: https://iis-students.ee.ethz.ch/lectures/vlsi-i/
1. Universal approximation with single- and multi-layer networks

2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory

3. Fundamental limits of deep neural network learning

4. Geometry of decision surfaces

5. Separating capacity of nonlinear decision surfaces

6. Vapnik-Chervonenkis (VC) dimension

7. VC dimension of neural networks

8. Generalization error in neural network learning

Lecture notes

Prerequisites / notice

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

### 227-0447-00L Image Analysis and Computer Vision

| Objective | Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises. |
| Content | This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given. |

Lecture notes

Prerequisites / notice

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

### 227-0468-00L Analog Signal Processing and Filtering

| Abstract | This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. |
| Objective | This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups. |
| Content | The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves. At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level. |

Lecture notes

Prerequisites / notice

The base for these lectures note complements This lecture very well in that respect. The course language is English.

### 227-0166-00L Analog Integrated Circuits

| Prerequisites / notice | Suitable for Master Students as well as Doctoral Students. |
| Lecture notes | Course material Script, computer demonstrations, exercises and problem solutions |

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

### 227-0521-00L Digital Image Processing

| Abstract | This course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given. |
| Objective | This course does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements This lecture very well in that respect. |
| Content | The base for these lectures note complements This lecture very well in that respect. The course language is English. |

Lecture notes

Prerequisites / notice

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c/oder=episodes , and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalfowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.
### 227-0477-00L  Acoustics I

**W** 3 credits  2G  K. Heutschi

**Abstract**
Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.

**Objective**
Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

**Content**
Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.

**Lecture notes**
Yes

### 227-0652-00L  Maxwell, Einstein, and the GPS

**W** 6 credits  2V+2U  T. Zambelli

**Abstract**
Maxwell’s equations are reinterpreted in the framework of Einstein’s special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

**Objective**
D-ITET is the depository of the Maxwell’s equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves. Only one aspect is left over: the fact that they are not invariant with respect to the classical Galilean transformation… On the contrary, Maxwell’s equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell’s equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

**Content**
- Galileo-Newton, the Ether, Michelson-Morley’s Experiment
- Lorentz Transformations
- 4-Vectors in Minkowski’s Spacetime: Tensor Calculus
- The Lagrangian, the Principle of Stationary Action for Particles and Fields, Noether’s Theorem
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac’s Effect
- GPS

**Lecture notes**
No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

**Literature**
- (Special Relativity) L. Susskind and A. Friedman, “Special Relativity and Classical Field Theory: The Theoretical Minimum”, 2019, Hachette Book Group USA
- (on the GPS) E.D. Kaplan, C. Hegarty, “Understanding GPS/GNSS”, 2017, ARTECH HOUSE USA

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 920 of 2416
Notions of a course on Electromagnetism like D-ITET "Electromagnetic Fields and Waves" are indispensable. Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.

IMPORTANT: a few Wednesdays are lectures (NOT exercises!), details in Moodle!

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>assessed</th>
<th>not assessed</th>
</tr>
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<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<tr>
<th>Method-specific Competencies</th>
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<tr>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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Social Competencies

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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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Personal Competencies

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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</table>

Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
- What is data?
- Bayesian Learning

Computational learning theory

Supervised learning:
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

Unsupervised learning:
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Lecture notes


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

263-4640-00L Network Security W 8 credits 2V+2U+3A A. Perrig, S. Frei, M. Legner, K. Paterson

Abstract

Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.
The course will cover topics spanning four broad themes with a focus on the first two themes:

1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

**Content**

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows: In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

**Prerequisites / notice**

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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401-3055-64L Algebraic Methods in Combinatorics

Does not take place this semester.

**Abstract**

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

**Content**

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows: In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

**Lecture notes**

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

**Prerequisites / notice**

Students are expected to have a mathematical background and should be able to write rigorous proofs.

227-0147-10L VLSI 3: Full-Custom Digital Circuit Design

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

At the end of this course, you will

• understand the design of the main digital blocks of state-of-the-art digital integrated circuits
• be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
• be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
• understand the performance trade-offs between delay, area, and power consumption

**Prerequisites / notice**

Students are expected to have a mathematical background and should be able to write rigorous proofs.

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• understand the performance trade-offs between delay, area, and power consumption

**Prerequisites / notice**

Students are expected to have a mathematical background and should be able to write rigorous proofs.
The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

Literature

N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

Prerequisites / notice

VLSI 3 can be taken in parallel with "VLSI 1: HDL-based design for FPGAs" and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Computers and Networks

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Computers and Networks"; see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

Core Courses

These core courses are particularly recommended for the field of "Computers and Networks". You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>L. Josipovic, L. Vanbever, R. Wattenhofer</td>
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</table>

Abstract

Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content

1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes Available
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed to be announced.

Understanding specific requirements and problems arising in embedded system applications.

M. Magno

Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of

Lecture Slides

Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

[bertsekas]  Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin]  Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998

[boudec]  Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras]  Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.

[fiat]  Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[schickinger]  Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steiger
Springer, Berlin, 2001

[sipser]  Introduction to the Theory of Computation
Michael Sipser.

227-0121-00L  Communication Systems  W  6 credits  4G  to be announced

Does not take place this semester.

Abstract
Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

Objective
Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

Content
Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Lecture notes
Lecture Slides

Literature

227-0124-00L  Embedded Systems  W  6 credits  4G  M. Magno, L. Thiele

Abstract
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

Objective
Understanding specific requirements and problems arising in embedded system applications.

Understanding architectures and components, their hardware-software interfaces, the memory architecture, communication between components, embedded operating systems, real-time scheduling theory, shared resources, low-power and low-energy design as well as hardware architecture synthesis.

Using the formal models and methods in embedded system design in practical applications using the programming language C, the operating system ThreadX, a commercial embedded system platform and the associated design environment.

Content
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems ThreadX, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://pbl.ee.ethz.ch/education/embedded-systems.html

Lecture notes
The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at https://pbl.ee.ethz.ch/education/embedded-systems.html

Literature


### Advanced Core Courses

Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>227-2210-00L</td>
<td>Computer Architecture</td>
<td>W</td>
<td>8</td>
<td>6G+1A</td>
<td>O. Mutlu</td>
</tr>
<tr>
<td>Abstract</td>
<td>Computer architecture is the science &amp; art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.</td>
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<td>Objective</td>
<td>We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicores processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g., graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.</td>
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<tr>
<td>Content</td>
<td>The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).</td>
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<td>Lecture notes</td>
<td>All the materials (including lecture slides) will be provided on the course website: <a href="https://safari.ethz.ch/architecture">https://safari.ethz.ch/architecture</a></td>
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<tr>
<td>Literature</td>
<td>See the course website for detailed and complete content of past incarnations of the course: <a href="https://safari.ethz.ch/architecture/">https://safari.ethz.ch/architecture/</a></td>
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<tr>
<td>Prerequisites / notice</td>
<td>Relevant references will be made available through the course website.</td>
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<tr>
<td>227-0575-00L</td>
<td>Advanced Topics in Communication Networks</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>L. Vanbever, R. Jacob</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover advanced topics in Internet routing and forwarding.</td>
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<td>Objective</td>
<td>The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be &quot;hands-on&quot; and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.</td>
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<td>Content</td>
<td>The course will cover advanced topics in Internet routing and forwarding such as:</td>
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<td>- Tunneling</td>
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<td>- Hierarchical routing</td>
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<td>- Traffic Engineering and Load Balancing</td>
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<td>- Virtual Private Networks</td>
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<td>- Quality of Service/Queuing/Scheduling</td>
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<td>- Fast Convergence</td>
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<td>- Network virtualization</td>
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<td>- Network programmability (OpenFlow, P4)</td>
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<td></td>
<td>- Network measurements</td>
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<tr>
<td>Lecture notes</td>
<td>The video recordings of the lectures will be made available on the course website: <a href="https://safari.ethz.ch/architecture/">https://safari.ethz.ch/architecture/</a></td>
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<tr>
<td>Literature</td>
<td>See <a href="https://safari.ethz.ch/architecture">https://safari.ethz.ch/architecture</a> for past examples.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.</td>
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<tr>
<td>Fostered competencies</td>
<td>Relevant references will be made available through the course website.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0579-00L</td>
<td>Hardware Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>K. Razavi</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.</td>
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Objective
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:
- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.
- writing critical reviews and academic discussions with peers on this topic.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature
Slides, relevant literature and manuals will be made available during the course.

Prerequisites / notice
Experience with Linux, systems programming and computer architecture.

252-1414-00L System Security

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side-channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-4640-00L Network Security

Abstract
Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content
The course will cover topics spanning four broad themes with a focus on the first two themes:
- network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
- network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
- analysis and inference topics such as traffic monitoring and network forensics; and
- new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

Prerequisites / notice
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

In the second part, the focus is on system design and methodologies for building secure systems. Students are assumed to have knowledge in networking as taught in 252-0064-00L or 227-0120-00L, or have experience in building large-scale systems. Experience with Linux, programming language such as C/C++, Go, Python, or Rust.

Fostered competencies
- Writing critical reviews and constructive discussions with peers on this topic.
- Hands-on techniques for performing hardware attacks.
- Relevant computer architecture and operating system aspects of these issues.
- Security problems of commodity hardware that we use everyday and how you can defend against them.

Specialisation Courses
These specialisation courses are particularly recommended for the area of “Computers and Networks”, but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.
### 227-0101-00L Discrete-Time and Statistical Signal Processing

<table>
<thead>
<tr>
<th>Abstract</th>
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<tbody>
<tr>
<td>The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, and the Viterbi algorithm.</td>
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<table>
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<tr>
<th>Objective</th>
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<tr>
<td>The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust &quot;inversion&quot; of a linear filter.</td>
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<table>
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<th>Content</th>
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<tbody>
<tr>
<td>1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.</td>
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<td>2. The discrete Fourier transform and its use for digital filtering.</td>
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<td>3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.</td>
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<tr>
<th>Lecture notes</th>
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<td>Lecture Notes</td>
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### 227-0103-00L Control Systems

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<th>Abstract</th>
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<tr>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
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<tbody>
<tr>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<table>
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<tr>
<th>Content</th>
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<tr>
<th>Literature</th>
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<tr>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>Prerequisites: Signal and Systems Theory II.</td>
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</table>

MATLAB is used for system analysis and simulation.

### 227-0116-00L VLSI 1: HDL Based Design for FPGAs

<table>
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<tr>
<th>Abstract</th>
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<tbody>
<tr>
<td>This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.</td>
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<table>
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<tr>
<th>Objective</th>
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<tbody>
<tr>
<td>Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.</td>
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<table>
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<tr>
<th>Content</th>
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<tbody>
<tr>
<td>This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include: Overview on design methodologies and fabrication depths. Levels of abstraction for circuit modeling. Organization and configuration of commercial field-programmable components. FPGA design flows. Dedicated and general purpose architectures compared. How to obtain an architecture for a given processing algorithm. Meeting throughput, area, and power goals by way of architectural transformations. Hardware Description Languages (HDL) and the underlying concepts. SystemVerilog. Register Transfer Level (RTL) synthesis and its limitations. Building blocks of digital VLSI circuits. Functional verification techniques and their limitations. Modular and largely reusable testbenches. Assertion-based verification. Synchronous versus asynchronous circuits. The case for synchronous circuits. Periodic events and the Anceau diagram. Case studies, ASICs compared to microprocessors, DSPs, and FPGAs. During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.</td>
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<table>
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<tr>
<th>Lecture notes</th>
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<tbody>
<tr>
<td>Textbook and all further documents in English.</td>
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<table>
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<tr>
<th>Literature</th>
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</table>
We discuss the following concepts related to fault-tolerant distributed systems: client-server, serialization, two-phase protocols, three-phase protocols, paxos, two generals problem, crash failures, impossibility of consensus, byzantine failures, agreement, termination, validity, consistency, durability, availability, fault tolerance, and replication.

### Artwork

#### Lecture notes

Comprehensive copy of transparencies

#### Literature


### Course material

- **Course material Script**, computer demonstrations, exercises and problem solutions
  - **Prerequisites**: Basic concepts of mathematical analysis and linear algebra. 
    The computer exercises are based on Python and Linux.
  - **Prerequisite notice**: The course language is English.

### Distribution Systems

#### Objective

The objective of the course is for students to understand the theoretical principles and practical considerations of distributed systems. This includes the main models of fault-tolerant distributed systems (crash failures, byzantine failures, and selfishness), and the most important algorithms, protocols and impossibility results. By the end of the course, students should be able to reason about various concepts such as consistency, durability, availability, fault tolerance, and replication.

#### Abstract

This course introduces the fundamentals of distributed systems. We study different protocols and algorithms that allow for fault-tolerant operation, and discuss practical systems that implement these techniques.

### Seminar in Computer Architecture

#### Objective

The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report and presentation at the end of the semester.

#### Abstract

In this seminar course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of multiple components that are aimed at improving students' technical skills in computer architecture, critical thinking and analysis on computer architecture concepts, as well as technical presentation of concepts and papers in both spoken and written forms.

### Notice

Enrolled students will be notified by e-mail about the lecture start.

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**Data:** 01.11.2022 12:41  
**Autumn Semester 2022**  
**Page 928 of 2416**
### Content

Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

See [https://safari.ethz.ch/architecture_seminar](https://safari.ethz.ch/architecture_seminar) for past examples.

### Lecture notes

All the materials will be posted on the course website: [https://safari.ethz.ch/architecture_seminar](https://safari.ethz.ch/architecture_seminar).

Links to past course materials, including the synthesis report assignment, can be found in this page: [https://safari.ethz.ch/architecture_seminar](https://safari.ethz.ch/architecture_seminar).

### Literature

Key papers and articles, on both fundamentals and cutting-edge topics in computer architecture will be provided and discussed. These will be posted on the course website.

See [https://safari.ethz.ch/architecture_seminar](https://safari.ethz.ch/architecture_seminar) for past examples.

### Prerequisites / notice

Design of Digital Circuits.
Students should have done very well in Digital Design and Computer Architecture ([https://safari.ethz.ch/digitaltechnik](https://safari.ethz.ch/digitaltechnik)) show a genuine interest in Computer Architecture research and practice.

### 151-0593-00L Embedded Control Systems

**Abstract**

This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

**Objectives**

- Familiarize students with main architectural principles and concepts of embedded control systems.
- An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

**Content**

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

**Lecture notes**

Lecture notes, lab instructions, supplemental material

**Prerequisites / notice**

Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at [www.mystudies.ethz.ch](http://www.mystudies.ethz.ch).

Detailed information can be found on the course website [http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html](http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html)

### 252-1411-00L Security of Wireless Networks

**Abstract**

Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.

**Objectives**

- After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.

**Content**


### 401-3055-64L Algebraic Methods in Combinatorics

**Abstract**

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objectives**

- The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

**Content**

Combination is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods. Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

**Notice**

The course website can be found at [https://moodle-app2.let.ethz.ch/course/view.php?id=15757](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Students are expected to have a mathematical background and should be able to write rigorous proofs.
Electronics and Photonics

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of “Electronics and Photonics”, see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor’s approval.

Core Courses

These core courses are particularly recommended for the field of “Electronics and Photonics”. You may choose core courses from other fields in agreement with your tutor.

Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0110-00L</td>
<td>Electromagnetic Waves: Materials, Effects, and Antennas</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>U. Koch</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.</td>
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<td>Objective</td>
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<td>You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions. You know how waves interact with matter and about nonlinear and resonant effects. You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.</td>
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<tr>
<td></td>
<td>Content</td>
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<td>The lecture covers the following topics:</td>
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<td>• Generic time-harmonic electromagnetic fields</td>
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<td>• Fundamental solutions of the wave equation</td>
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<td></td>
<td>• Wave propagation in various types of materials</td>
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<td>• Interaction of waves with matter</td>
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<td></td>
<td>• Nonlinear effects</td>
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<td>• Resonant effects</td>
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<td></td>
<td>• Applications like scattering, waveguiding, radiation</td>
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<td></td>
<td>• Radio frequency and optical antennas</td>
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<td>Lecture notes</td>
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<td>Lecture notes and slides will be handed out during the lectures.</td>
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<td>Prerequisites / notice</td>
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<td>Remark: the lecture succeeds “Advanced Electromagnetic Waves” and reorientates itself to materials, effects, and applications with waves.</td>
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| 227-0116-00L | VLSI 1: HDL Based Design for FPGAs | W    | 6 credits | 5G   | F. K. Gürkaynak, L. Benini |
|          | Abstract                                        |      |       |       |                       |
|          | This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits. |
|          | Objective                                       |      |       |       |                       |
|          | Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools. |
|          | Content                                         |      |       |       |                       |
|          | This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include: |
|          | - Overview on design methodologies and fabrication depths. |
|          | - Levels of abstraction for circuit modeling. |
|          | - Organization and configuration of commercial field-programmable components. |
|          | - FPGA design flows. |
|          | - Dedicated and general purpose architectures compared. |
|          | - How to obtain an architecture for a given processing algorithm. |
|          | - Meeting throughput, area, and power goals by way of architectural transformations. |
|          | - Hardware Description Languages (HDL) and the underlying concepts. |
|          | - SystemVerilog |
|          | - Register Transfer Level (RTL) synthesis and its limitations. |
|          | - Building blocks of digital VLSI circuits; |
|          | - Functional verification techniques and their limitations. |
|          | - Modular and largely reusable testbenches. |
|          | - Assertion-based verification. |
|          | - Synchronous versus asynchronous circuits. |
|          | - The case for synchronous circuits. |
|          | - Periodic events and the Anceau diagram. |
|          | - Case studies, ASICs compared to microprocessors, DSPs, and FPGAs. |
|          | Lecture notes                                   |      |       |       |                       |
|          | Textbook and all further documents in English. |
|          | Literature                                      |      |       |       |                       |
|          | Prerequisites / notice                          |      |       |       |                       |
|          | Basics of digital circuits. |
|          | Examination:                                    |      |       |       |                       |
|          | In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German. |
|          | Further details:                                |      |       |       |                       |
|          | [https://iis-students.ee.ethz.ch/lectures/vlsi-i/](https://iis-students.ee.ethz.ch/lectures/vlsi-i/) |

| 227-0145-00L | Solid State Electronics and Optics | W    | 6 credits | 4G   | N. Yazdani, V. Wood |
|          | Abstract                                        |      |       |       |                       |
|          | “Solid State Electronics” is an introductory condensed matter physics course covering crystal structure, electron models, classification of metals, semiconductors, and insulators, band structure engineering, thermal and electronic transport in solids, magnetoresistance, and optical properties of solids. |
|          | Objective                                       |      |       |       |                       |
|          | Understand the fundamental physics behind the mechanical, thermal, electric, magnetic, and optical properties of materials. |
This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over design procedure for a single-loop modulator.

**Objective**
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

**Content**
- Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, present mirrors, supply independent biasing etc;
- Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitor circuits.
- The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

**Literature**

**Prerequisites / notice**
- It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

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**Advanced Core Courses**

Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
227-0146-00L | Analog-to-Digital Converters | W | 6 credits | 2V+2U | T. Burger

**Abstract**
This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.

**Objective**
Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. The student will learn to understand the basic principles behind data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or arithmetic conversion are explained with their principle of operation accompanied with the appropriate mathematical calculations, including the effects of non-idealties in some cases. After successful completion of the course the student should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.

**Content**
- Introduction: information representation and communication; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.  
- Dual-slope & successive approximation register (SAR) converters: dual slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.  
- Algorithmic & pipelined A/D converters: algorithmic conversion principle; sample & hold stage; pipelined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.  
- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.  
- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkler correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.  
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.  
- Delta-sigma A/D-converters: linearity and resolution; from modulation to delta-sigma modulation; first-order delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.  

**Literature**
- M. Gustavsson et al., CMOS Data Converters for Communications, Springer, 2010

**Prerequisites / notice**
- It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

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**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
227-0301-00L | Optical Communication Fundamentals | W | 6 credits | 2V+1U+1P | J. Leuthold

**Abstract**
The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

**Objective**
An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the impact such elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

**Content**
- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, QCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

**Literature**
- Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

**Prerequisites / notice**
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<tr>
<td>227-0655-00L</td>
<td>Nonlinear Optics</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>J. Leuthold</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematically by means of the susceptibility. Participants will be able to designing and invent novel phononic, plasmonic or quantum devices.</td>
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<td>Chapter 1: The Wave Equations in Nonlinear Optics</td>
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<td>Chapter 2: Nonlinear Effects - An Overview</td>
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<td>Chapter 3: The Nonlinear Optical Susceptibility - Classical and Quantummechancal Derivations</td>
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<td>Chapter 4: Second Harmonic Generation</td>
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<td>Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator</td>
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<td>Chapter 6: Accousto-Optic Effect</td>
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<td>Chapter 7: Nonlinear Effects of Third Order</td>
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<td>Chapter 8: Nonlinear Effects in Media with Gain</td>
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<td>Lecture notes are distributed. For students enrolled in the course, additional information, lecture notes and exercises can be found on moodle (<a href="https://moodle-appc.let.ethz.ch/">https://moodle-appc.let.ethz.ch/</a>).</td>
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<tr>
<td></td>
<td>Fundamentals of Electromagnetic Fields (Maxwell Equations) &amp; Bachelor Lectures on Physics</td>
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<tr>
<td>227-0663-00L</td>
<td>Nano-Optics</td>
<td>W</td>
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<td>M. Frimmer</td>
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<td></td>
<td>Abstract</td>
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<td>Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.</td>
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<td></td>
<td>Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.</td>
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<td>We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.</td>
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<td>- Electromagnetic fields and (or) equivalent</td>
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<td>- Physics I+II</td>
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<td>This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.</td>
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<td>At the end of this course, you will</td>
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<td>• understand the design of the main building blocks of state-of-the-art digital integrated circuits</td>
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<td>• be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels</td>
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<td>• be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits</td>
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<td>• understand the performance trade-offs between delay, area, and power consumption</td>
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<td>Content</td>
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<td>The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:</td>
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<td>• Nanometer MOSFETs</td>
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<td>• Static and dynamic behavior of complementary MOS (CMOS) inverters</td>
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<td>• CMOS gate design, sizing, and timing</td>
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<td>• Full-custom standard-cell design</td>
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<td>• Wire models and parasitics</td>
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<td>• Latch and flip-flop circuits</td>
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<td>• Gate-level timing analysis and optimization</td>
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<td>• Static and dynamic power consumption; low-power techniques</td>
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<td></td>
<td>• Alternative logic styles (dynamic logic, pass-transistor logic, etc.)</td>
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<td></td>
<td>• Arithmetic and logic circuits</td>
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<td>• Fixed-point and floating-point arithmetic</td>
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<td></td>
<td>• Synchronous and asynchronous design principles</td>
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<td>• Memory circuits (ROM, SRAM, and DRAM)</td>
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<td>• In- and near-memory processing architectures</td>
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<td>• Full-custom accelerator circuits for machine learning</td>
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<td>The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.</td>
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<td></td>
<td>N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley</td>
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<td>VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.</td>
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<tr>
<td>227-0121-00L</td>
<td>Communication Systems</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>to be announced</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td>Abstract</td>
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<td>Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet</td>
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<tr>
<td></td>
<td>Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems</td>
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Content
Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Lecture notes
Lecture Slides

Literature

227-0155-00L Machine Learning on Microcontrollers  ●  W  6 credits  4G  M. Magno, L. Benini
Registration in this class requires the permission of the instructors. Class size will be limited to 25. Preference is given to students in the MSc EEIT.

Abstract
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

Objective
Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras,...). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

Content
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:
- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercises will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Lecture notes
Script and exercise sheets. Books will be suggested during the course.

Prerequisites / notice

227-0157-00L Semiconductor Devices: Physical Bases and Simulation  W  4 credits  3G  A. Schenk, C. I. Roman

Abstract
The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulation of the most important devices and of interesting physical effects supplement the lectures.

Objective
The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

Content
The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic modeling), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

Lecture notes
The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

Literature
The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Prerequisites / notice

227-0166-00L Analog Integrated Circuits  W  6 credits  2V+2U  T. Jang

Abstract
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

Objective
The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Content
Review of the bipolar and MOS devices and their small-signal equivalent circuit models. Building blocks in analog circuits such as current sources, active load, current mirrors, active independent biasing etc; Amplifiers, differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes
Handouts of presented slides. No script but an accompanying textbook is recommended.

Literature

227-0377-10L Physics of Failure and Reliability of Electronic Devices and Systems  W  3 credits  2V  I. Shorubalko, M. Held

Abstract
This course evaluates the physical and electrical aspects of the failure processes of electronic devices. It describes the failure mechanisms and their effects. The concepts of failure processes are presented by means of examples from real engineering applications. The intention of the course is to bridge the gap between the physics of semiconductors and the reliability of electronic systems.

Objective
The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulation of the most important devices and of interesting physical effects supplement the lectures.

Content
The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

Lecture notes
The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

Literature
The script (in book style) is sufficient. Further reading will be recommended in the lecture.

Prerequisites / notice
Abstract
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

Objective
Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Lecture notes
Comprehensive copy of transparencies

Literature

227-0468-00L Analog Signal Processing and Filtering
W 6 credits 2V+2U H. Schmid
Suitable for Master Students as well as Doctoral Students.

Abstract
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

Objective
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

Content
At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

Lecture notes
The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes , and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites / notice
Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed
Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed
Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

227-0615-00L Simulation of Photovoltaic Devices - From Materials to Modules
W 3 credits 2G U. Aeberhard

Abstract
The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules and large scale photovoltaic systems.

Objective
Get an overview over the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to predict the performance of solar cells and modules.
Content
Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)

Literature

Prerequisites / notice
Undergraduate physics, mathematics, semiconductor devices

Fostered competencies

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Social Competencies

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Personal Competencies

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227-0617-00L Solar Cells

| Objective | Introduce to solar radiation, physics, technology, characteristics and applications of photovoltaic solar cells. |
| Content   | Solar radiation characteristics, physical mechanisms for the light to electrical power conversion, properties of semiconductors for solar cells, processing and properties of conventional Si and GaAs based solar cells, technology and physics of thin film solar cells based on compound semiconductors, other solar cells including organic and dye sensitized cells, problems and new developments for power generation in space, interconnection of cells and solar module design, measurement techniques, system design of photovoltaic plants, system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples. |
| Lecture notes | Lecture reprints (in english). |
| Prerequisites / notice | Prerequisites: Basic knowledge of semiconductor properties. |

227-0618-00L Modeling, Characterization and Reliability of Power Semiconductors

| Objective | This lecture provides theoretical and experimental knowledge on the techniques for the characterization and numerical modeling of power semiconductors, as well on the related built-in reliability strategies. |
| Content   | The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems. |
| Lecture notes | Handouts to the lecture (approx. 250 pp.) |

227-0619-00L Charge Transport in Energy Conversion and Storage Devices

| Objective | This lecture provides theoretical and experimental knowledge on the techniques for the characterization and numerical modeling of power semiconductors, as well on the related built-in reliability strategies. |
| Content   | The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems. |
| Lecture notes | Handouts to the lecture (approx. 250 pp.) |

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 935 of 2416
By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolyzers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

**Prerequisites / notice**

Be motivated to change the world to renewable energies! Elements of calculus will be reviewed at the beginning of the course, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite. Students are required to bring a Windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students. A visit to a solar cell or battery fab will be organized during the semester if the epidemiological situation permits.

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<th>227-0652-00L</th>
<th>Maxwell, Einstein, and the GPS</th>
<th>W</th>
<th>6 credits</th>
<th>2V+2U</th>
<th>T. Zambelli</th>
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**Abstract**

Maxwell’s equations are reinterpreted in the framework of Einstein’s special relativity theory using the Lagrangian formalism in order to discover the deep interconnection between the electric and magnetic field. Its daily relevance is emphasized by pinpointing how GPS atomic clocks in satellites and on the earth are affected by frequency shifts which can be explained only in terms of relativity.

**Objective**

D-ITET is the depository of the Maxwell’s equations, which are dissected from all perspectives in the courses Physics I, Electromagnetic Fields and Waves, and Advanced Electromagnetic Waves.

Only one aspect is left over; the fact that they are not invariant with respect to the classical Galilean transformation… On the contrary, Maxwell’s equations predict that the light speed is the same for every inertial frame of reference. In this course, we will deepen how Einstein solved this clash elaborating the theory of “special relativity”. Maxwell’s equations are thus naturally derived in a breath-taking fashion from the principle of stationary action within the Lagrangian formalism.

Not only its elegance, but also the daily importance of the relativity theory will be finally highlighted explaining how the GPS can work only if the relativistic view of synchronous clocks is taken into account.

**Content**

- Galileo-Newton, the Ether, Michelson-Morley’s Experiment
- Lorentz Transformations
- 4-Vectors in Minkowski’s Spacetime: Tensor Calculus
- The Lagrangian, the Principle of Stationary Action for Particles and Fields, Noether’s Theorem
- Maxwell’s Equations and the Energy-Momentum Tensor
- Waves
- Radiation from Accelerated Charged Particles
- Sagnac’s Effect
- GPS

**Lecture notes**

No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

**Literature**

- (Special Relativity) L. Susskind and A. Friedman, “Special Relativity and Classical Field Theory: The Theoretical Minimum”, 2019, Hachette Book Group USA

Supplementary material will be uploaded in Moodle.

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+ (on the GPS) E.D. Kaplan, C. Hegarty, “Understanding GPS/GNSS”, 2017, ARTECH HOUSE USA

**Prerequisites / notice**

Notions of a course on Electromagnetism like D-ITET “Electromagnetic Fields and Waves” are indispensable.

Furthermore, a solid base of Analysis I & II as well as of Linear Algebra is really helpful.

**IMPORTANT:** a few Wednesdays are lectures (NOT exercises!), details in Moodle!

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 936 of 2416
Abstract: The seminar aims at instructing graduate and PhD students in the basics of presentation techniques, i.e. "how to give a professional talk". Attendees have the possibility to become acquainted with a current topic by a literature study, and to present the results thereof in a 20 minutes talk in English. The participation at the seminar gives also an overview on current problems in modern nano- and opto-electronics.

Content: The seminar topics' are simulation of nanoelectronic processes and devices, and the optical as well as electronic simulation of optoelectronic devices as lasers, photodiodes, etc.

Lecture notes: The students learn how to find the right literature for a certain topic quickly, as well as how to prepare a talk for a scientific conference, i.e. presentation techniques.

Prerequisites / notice: 1. Electrodynamics 2. Physics 1.2 3. Introduction to quantum mechanics

227-0655-00L Battery Integration Engineering

Abstract: Batteries enable sustainable mobility, renewable power integration, various power grid services, and residential energy storage. Linked with low cost PV, Li-ion batteries are positioned to shift the 19th-century centralized power grid into a 21st-century distributed one. As with battery integration, this course combines understanding of electrochemistry, heat & mass transfer, device engineering.

Objective: The learning objectives are:
- Apply critical thinking on advancements in battery integration engineering. Assessment reflects this objective and is based on review of a scientific paper, with mark weighting of 10 / 25 / 65 for a proposal / oral presentation / final report, respectively.
- Design battery system concepts for various applications in the modern power system and sustainable mobility, with a deep focus on replacing diesel buses with electric buses combined with charging infrastructure.
- Critically assess progresses in battery integration engineering: from material science of novel battery technologies to battery system design.
- Apply "lessons learned" from the history of batteries to assess progress in battery technology.
- Apply experimental and physical concepts to develop battery models in order to predict lifetime.
- Battery systems for the modern power grid and sustainable mobility.
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.
- Sustainability and life cycle analysis of battery system innovations.

Content:
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Battery systems for the modern power grid and sustainable mobility.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.
- Sustainability and life cycle analysis of battery system innovations.

Prerequisites / notice: Limited to 30 Students. Priority given to Electrical and Mechanical Engineering students.

Mandatory - background knowledge in batteries & electrochemistry acquired in one of the following courses:
- 227-0664-00L Technology and Policy of Electrical Energy Storage
- 529-0440-01L Physical Electrochemistry and Electrocatalysis
- 529-0191-01L Renewable Energy Technologies II, Energy Storage and Conversion
- 529-0659-00L Electrochemistry (Exception for PhD students).

Exception given for PhD students.
Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict them at least niche applications for ever-growing hardware market. However, some of these technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now.

Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other's. Selecting to study one technology in more details, students will evaluate its potential and acquire important presenting and critical thinking skills.

The course is organized as a series of lectures, which are synchronized with student group projects, focusing on selected memory technologies. Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 3 presentations (20-25 min each), followed the example given by the lecturer.

Lecture notes will be made available on the website.
### Embedded MEMS Lab

This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**

Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System) and carry out the fabrication of an accelerometer. Students carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and evaluated in a final report. Limited access is available.

**Content**

With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:

- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

**Prerequisites / notice**

Participating students are required to attend all scheduled lectures and meetings of the course. Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

- Priority 1: master students of the master's program in "Micro and Nanosystems"
- Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Daraio, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
- Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
- Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

| Lecture notes | All the materials will be posted on the course website: https://safari.ethz.ch/architecture_seminar/ | Links to past course materials, including the synthesis report assignment, can be found in this page: https://safari.ethz.ch/architecture_seminar |
| Literature | Key papers and articles, on both fundamentals and cutting-edge topics in computer architecture will be provided and discussed. These will be posted on the course website. | See https://safari.ethz.ch/architecture_seminar for past examples. |
| Prerequisites / notice | Design of Digital Circuits. Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice. |  

**151-0601-00L Theory of Robotics and Mechatronics**  
No take place this semester.  

**Abstract**

This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**

Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**

An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**

A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

**Literature**

The document provides sufficient information for the participants to successfully participate in the course.

**Prerequisites / notice**

Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

- Priority 1: master students of the master's program in "Micro and Nanosystems"
- Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Daraio, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
- Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
- Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

**151-0620-00L Embedded MEMS Lab**  
**4 credits**  
W  
3G  
C. Hierold, M. Haluska

**Abstract**

Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access

**Objective**

Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

**Content**

With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:

- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

**Lecture notes**

A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

**Literature**

The document provides sufficient information for the participants to successfully participate in the course.

**Prerequisites / notice**

Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

- Priority 1: master students of the master's program in “Micro and Nanosystems”
- Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Daraio, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
- Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
- Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

**151-0605-00L Nanosystems**  
**4 credits**  
A. Stemmer

**Abstract**

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.

**Objective**

Familiarize students with basic science and engineering principles governing the nano domain.
The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) Interaction Forces on the Micro and Nano Scale

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.


(II) From Quantum to Continuum

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

-      Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes
-      Analyse the relationship between individual and organizational decision processes and their innovative outcomes
-      Analyse the relationship between individual and organizational decision processes and their innovative outcomes
-      Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

This course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

This course intends to enable all students to:

This course focuses on technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

The course content and methods are designed for students with some background in management and/or economics. Familiarity with basic concepts of quantum mechanics is expected.

-      Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes
-      Analyse the relationship between individual and organizational decision processes and their innovative outcomes
-      Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes
-      Analyse the relationship between individual and organizational decision processes and their innovative outcomes

The course will focus on the growth of multi-ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation

Abstract

The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

Objective

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

Content

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

363-0389-00L Technology and Innovation Management

Abstract

This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

Objective

This course intends to enable all students to:

-      Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes
-      Analyse the relationship between individual and organizational decision processes and their innovative outcomes
-      Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes
-      Analyse the relationship between individual and organizational decision processes and their innovative outcomes

Content

This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Lecture notes

Slides will be available on the Moodle page

Literature

Readings will be available on the Moodle page

Prerequisites / notice

The course content and methods are designed for students with some background in management and/or economics

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Personal Competencies

Critical Thinking

376-1176-00L Wearable and Mobile Technologies of the Future - Focus on Sports and Health

Abstract

This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.
Objective 1:
Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2:
Acquire skills to design novel non-invasive technologies for sport and health.

Content
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3055-64L</td>
<td>Algebraic Methods in Combinatorics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>B. Sudakov</td>
</tr>
</tbody>
</table>

Abstract
Combining combinatorics with other mathematical disciplines such as graph theory, linear algebra, and probability theory, Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content
Combining combinatorics with other mathematical disciplines such as graph theory, linear algebra, and probability theory, Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods,
- Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem.
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice
Students are expected to have a mathematical background and should be able to write rigorous proofs.

>>> Energy and Power Electronics

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Energy and Power Electronics". See https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

>>> Core Courses

These core courses are particularly recommended for the field of "Energy and Power Electronics". You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

>>> Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0113-00L</td>
<td>Power Electronics</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>J. W. Kolar</td>
</tr>
</tbody>
</table>

Abstract
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Lecture notes
Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice
Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Assessed
4G
W

Abstract
This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

Objective
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

Content
- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes
Lecture notes and associated exercises including correct answers

Advanced Core Courses
Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

Number Title Type ECTS Hours Lecturers
227-0017-00L High Voltage Engineering W 6 credits 4G C. Franck, U. Straumann

Abstract
High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, .... High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages.

Objective
The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify of weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

Content
- discussion of the field equations relevant for high voltage engineering.
- analytical and numerical solutions/solving of this equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components

Lecture notes
Lecture Slides

Literature
This course introduces different electric machine concepts and provides a deeper understanding of their detailed operating principles. The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

### Specialisation Courses

These specialisation courses are particularly recommended for the area of "Energy and Power Electronics", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>
Abstract The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content 1. Discrete-time linear systems and filters:
state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes Lecture Notes

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227-0103-00L Control Systems W 6 credits 2V+2U F. Dörfler

Abstract Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.


Prerequisites / notice Prerequisites: Signals and Systems Theory I.

MATLAB is used for system analysis and simulation.

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227-0121-00L Communication Systems W 6 credits 4G to be announced

Does not take place this semester.

Abstract Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example and Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

Objective Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

Content Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Lecture notes Lecture Slides


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227-0225-00L Linear System Theory W 6 credits 5G J. Lygeros, A. Tsiatsis

Abstract The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content - Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes Available on the course Moodle platform.

Prerequisites / notice Sufficient mathematical maturity, in particular in linear algebra, analysis.

Fostered competencies Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Personal Competencies: Integrity and Work Ethics not assessed

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227-0517-10L Fundamentals of Electric Machines W 6 credits 4G D. Borts, R. Bosshard

Abstract

Objective

Content

Lecture notes

Literature

Prerequisites / notice

Fostered competencies

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Abstract
This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

Objective
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

Content
- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes
Lecture notes and associated exercises including correct answers

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Lecture Hours</th>
<th>Tutorial Hours</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>227-0523-00L</td>
<td>Railway Systems I</td>
<td>6</td>
<td>4G</td>
<td>M. Meyer</td>
<td></td>
</tr>
<tr>
<td>227-0536-00L</td>
<td>Multiphysics Simulations for Power Systems</td>
<td>4</td>
<td>2V+2U</td>
<td>J. Smajic</td>
<td></td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 945 of 2416
Lecture reprints (in english).
Handouts to the lecture (approx. 250 pp.)

M. P. M. Ciappa, R. Carron, W. F. Krismer

1. Basic knowledge of design and optimization of a power electronic system; furthermore, lecture and exercises thoroughly discuss key topics of power electronics.

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgears (GIS)
   f. Electromagnetic compatibility (EMC)

227-0567-00L Design of Power Electronic Systems 4 credits 4G F. Krismer

Abstract
Complete design process: from given specifications to a complete power electronic system; selection / design of suitable passive power components; static and dynamic properties of power semiconductors; optimized EMI filter design; heat sink optimization; additional circuitry, e.g. gate driver; system optimization.

Objective
Basic knowledge of design and optimization of a power electronic system; furthermore, lecture and exercises thoroughly discuss key topics of power electronics that are important with respect to a practical realization, e.g. how to select suitable power components, to understand switching operations, calculation of high frequency losses, EMI filter design and realization, thermal considerations.

Content
Complete design process: from given specifications to a complete power electronic system
Selection and / or design of suitable passive power components: specific properties, parasitic components, tolerances, high frequency losses, thermal considerations, reliability.
Static and dynamic characteristics of power semiconductors.
Optimized design of the EMI filter.
Thermal characterization of the converter, optimized heat sink design.
Additional circuitry: gate driver, measurement, control.
Converter start up: typical sequence of events, circuity required.
Overall system optimization: identifying couplings between different components of the considered power electronic system, optimization targets and issues.

Lecture notes 
Lecture notes and complementary exercises including correct answers.

Prerequisites / notice
Prerequisites: Introductory course on power electronics.

227-0617-00L Solar Cells 4 credits 3G A. N. Tiwari, R. Carron, Y. Romanyuk

Abstract
Physics, technology, characteristics and applications of photovoltaic solar cells.

Objective
Introduction to solar radiation, physics, technology, characteristics and applications of photovoltaic solar cells and systems.

Content
Solar radiation characteristics, physical mechanisms for the light to electrical power conversion, properties of power semiconductors for solar cells, processing and properties of conventional Si and GaAs based solar cells, technology and physics of thin film solar cells based on compound semiconductors, other solar cells including organic and dye sensitized cells, problems and new developments for power generation in space, interconnection of cells and solar module design, measurement techniques, system design of photovoltaic plants, system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples.

Lecture notes
Lecture reprints (in english).

Prerequisites / notice
Prerequisites: Basic knowledge of semiconductor properties.

227-0618-00L Modeling, Characterization and Reliability of Power Semiconductors 4 credits 4G M. P. M. Ciappa

Abstract
This lecture provides theoretical and experimental knowledge on the techniques for the characterization and numerical modeling of modern power semiconductor devices, as well as on the related built-in reliability strategies.

Objective
The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.

Content
This lecture consists of a theoretical part (50%) and of laboratory exercises and demonstrations (50%).

The theoretical part covers the basic techniques and procedures for characterization, modeling and built-in reliability of modern power semiconductor devices with special attention to MOS and IGBT. The starting part on technology provides an overview on the main device families and includes a review of the most relevant application-oriented aspects of the device physics, thermal management, and packaging. The second section deals with the basic experimental characterization techniques for the definition of the semiconductor material properties, electrical characteristics, safe operating area, and junction temperature of the devices. The following section introduces the basic principles for electrical, thermal, and electro-thermal simulation of power semiconductors by Technology Computed Aided Design (TCAD) and compact modeling. Finally, procedures are methods are presented to implement efficient built-in reliability programs targeted on power semiconductors. They include failure physics, dedicated failure analysis techniques, accelerated testing, defect screening, and lifetime modeling.

During the laboratory activities, selections of the experimental techniques presented in the lecture are demonstrated on the base of realistic examples. Furthermore, schematic power devices will be simulated by the students with advanced TCAD tools and circuit simulators.

Lecture notes
Handouts to the lecture (approx. 250 pp.)
227-0619-00L Charge Transport in Energy Conversion and Storage Devices

**Abstract**
The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolyzers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.

**Objective**
By the end of the course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolyzers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

**Literature**
R. Huggins: Advanced Batteries, DOI:10.1007/9780387987424

**References**
Will be given at the end of individual lectures.

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227-0609-00L Industrial Process Control

**Abstract**
Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing.

**Objective**
General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends.

**Content**
- Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering.
- Differences and characteristics of discrete and process industries.
- Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets.
- Practical analysis and design of closed-loop control for the process industry.
- Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequential control, structured text);
- PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabinets, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus).
- Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.
- Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.

**Lecture notes**
Slides will be available as PDF documents, see "Learning materials" (for registered students only).

**Prerequisites / notice**
References will be given at the end of individual lectures.

**Exercises:** Tuesday 15-16

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227-0731-00L Power Market I - Portfolio and Risk Management

**Abstract**
Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

**Objective**

**Content**
- Pan-European power market and trading
- 1.1. Power trading
- 1.2. Development of the European power markets
- 1.3. Energy economics
- 1.4. Spot and OTC trading
- 1.5. European energy exchange EEX

- 2. Market model
  2.1. Market place and organisation
  2.2. Balance groups / balancing energy
  2.3. Ancillary services
  2.4. Market for ancillary services
  2.5. Cross-border trading
  2.6. Capacity auctions

- 3. Portfolio and Risk management
  3.1. Portfolio management 1 (introduction)
  3.2. Forward and futures contracts
  3.3. Risk management 1 (m2m, VaR, hpf, volatility, cVaR)
  3.4. Risk management 2 (PaR)
  3.5. Contract valuation (HPFC)
  3.6. Portfolio management 2

- 4. Energy & Finance
  4.1. Options 1 basics
  4.2. Options 2 hedging with options
  4.3. Introduction to derivatives (swaps, cap, floor, collar)
  4.4. Financial modelling of physical assets
  4.5. Trading and hydro power
  4.6. Incentive regulation

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**Lecture notes**
Handouts of the lecture

**Prerequisites / notice**
1 excursion per semester, 2 case studies, guest speakers for specific topics.

Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636
Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing.

A. Horch

W - Proof techniques and practices.

Available on the course Moodle platform.

Analytical Competencies

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

ECTS 6 credits

2V+2U

F. Dörfler


Prerequisites / notice

Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

Linear System Theory

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

ECTS 6 credits

5G

J. Lygeros, A. Tsiotras

Content

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Literature


Prerequisites / notice

Available on the course Moodle platform.

Sufficient mathematical maturity, in particular in linear algebra, analysis.

Industrial Process Control

Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing.

ECTS 4 credits

3G

A. Horch, L. Dominguez Palomeque

Abstract

Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries. Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.

Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text); PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.

Analysis of control systems for single input - single output and multivariable systems. Differences and characteristics of discrete and process industries.

Lecture notes

Slides will be available as .PDF documents, see "Learning materials" (for registered students only)

Literature

References will be given at the end of individual lectures.
Prerequisites / notice

Exercises: Tuesday 15-16

Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0371-00L</td>
<td>Advanced Model Predictive Control</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
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<td><strong>Number of participants limited to 60.</strong></td>
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<tr>
<td>Abstract</td>
<td>Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.</td>
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<tr>
<td>Objective</td>
<td>Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.</td>
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<tr>
<td>Content</td>
<td>Topics include - Nominal MPC for uncertain systems (nominal robustness) - Robust MPC - Stochastic MPC - Review of regression methods - Set-membership Identification and robust data-driven MPC - Bayesian regression and stochastic data-driven MPC - MPC as safety filter for reinforcement learning</td>
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<td>Lecture notes</td>
<td>Lecture notes will be provided.</td>
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<td>Prerequisites / notice</td>
<td>Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended. Background in linear algebra and stochastic systems recommended.</td>
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151-0563-01L Dynamic Programming and Optimal Control

W 4 credits 2V+1U R. D’Andrea

Abstract

Introduction to Dynamic Programming and Optimal Control.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature


Prerequisites / notice

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Specialisation Courses

These specialisation courses are particularly recommended for the area of "Systems and Control", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the Master's Programme.

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<thead>
<tr>
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<tbody>
<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
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<tr>
<td>Abstract</td>
<td>Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.</td>
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<tr>
<td>Objective</td>
<td>Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss). The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems. In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.</td>
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<tr>
<td>Lecture notes</td>
<td>Available</td>
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</table>
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

The course language is English.

Prerequisites:
- Basic concepts of mathematical analysis and linear algebra.
- The computer exercises are based on Python and Linux.
- The course language is English.

Literature
- [bersekas] Data Networks
  Dimitri Bersekas, Robert Gallager
- [borodin] Online Computation and Competitive Analysis
  Allan Borodin, Ran El-Yaniv.
  Cambridge University Press, 1998
- [boudec] Network Calculus
  J.-Y. Le Boudec, P. Thiran
  Springer, 2001
- [cassandras] Introduction to Discrete Event Systems
  Christos Cassandras, Stéphane Lafortune.
- [fiat] Online Algorithms: The State of the Art
  A. Fiat and G. Woeginger
  D. Hochbaum
- [schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
  T. Schickinger, A. Steger
  Springer, Berlin, 2001
- [sipser] Introduction to the Theory of Computation
  Michael Sipser.

227-0447-00L Image Analysis and Computer Vision

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material, script, computer demonstrations, exercises and problem solutions.

Prerequisites / notice
- Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

227-0526-00L Power System Analysis

Abstract
The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Objective
The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis tools in steady and dynamic states.

Content
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes
Lecture notes.

227-0689-00L System Identification

Abstract
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Objective
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Content
Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Literature

Additional papers will be available via the course Moodle.

Prerequisites / notice
- Control systems (227-0216-00L) or equivalent.

227-0945-00L Cell and Molecular Biology for Engineers I

Does not take place this semester.
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

**Objective**
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

**Content**
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

**Lecture notes**
Scripts of all lectures will be available.

**Literature**

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**151-0532-00L Nonlinear Dynamics and Chaos I**

**Abstract**
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

**Objective**
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

**Content**
1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

**Lecture notes / notice**
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

**Prerequisites**
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.

- Exam: two-hour written exam in English.

- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

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**151-0573-00L System Modeling**

**Abstract**
Introduction to system modeling for control. Generic modeling approaches based on first principles, Lagrangian formalism, energy approaches and experimental data. Model parametrization and parameter estimation. Basic analysis of linear and nonlinear systems.

**Objective**
Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.

**Content**
This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.

**Lecture notes**
The handouts in English will be available in digital form.

**Literature**
A list of references is included in the handouts.
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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151-0601-00L  
**Theory of Robotics and Mechatronics**

W 4 credits 3G to be announced

**Abstract**
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Lecture notes available.

151-0563-01L  
**Dynamic Programming and Optimal Control**

W 4 credits 2V+1U R. D'Andrea

**Abstract**
Introduction to Dynamic Programming and Optimal Control.

**Objective**
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

**Literature**

**Prerequisites / notice**
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

151-9905-00L  
**Applied Compositional Thinking for Engineers II**

E- 4 credits 3G A. Censi, J. Lorand

**Abstract**
This course is an introduction to advanced topics in Applied Category Theory focused on the needs of applications. The course favors a computational, constructive, and compositional approach targeted to applications in engineering.

**Objective**
In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of problems and the design of solutions. Applied Category Theory is a field of mathematics that can help in thinking about precisely such topics. A problem, however, is that this type of mathematics is not traditionally taught -- to date, there exists no easy path for engineers to learn category theory that is approachable and emphasizes engineering applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I).

This course's goal is not to teach category theory for the sake of it, but to teach the "compositional way of thinking". Category theory will just be the means towards this end. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.

The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.
### Content

**Categories**
- Functors
- Co-design problems
- Natural transformations
- Adjunctions
- Traced monoidal categories

**Computation:**
- From mathematical models to algorithms
- Solving finite co-design problems
- Monads
- Modeling uncertainty

**Enriched category theory:**
- Profunctors
- Enriched categories
- Negative category theory

**Operads**

**Linear logic and resources**

**Lecture notes**

Slides and notes will be provided.

**Literature**


**Prerequisites / notice**

The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1. Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2. Basic algebra (sets, posets, relations, semigroups, groups).

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in the Spring Semester are sufficiently proficient in (1) and (2).

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lectures</th>
<th>Teachers</th>
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</thead>
<tbody>
<tr>
<td>376-1219-00L</td>
<td>Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions</td>
<td>W 3 credits 2V</td>
<td>R. Rieder, O. Lamberty</td>
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</tbody>
</table>
**Introduction to Mathematical Optimization**

**Prerequisites / notice**


**Objective**

The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

**Content**

Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

**Literature**

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

**401-0647-00L**

**Introduction to Mathematical Optimization**

- **W** 5 credits
- **2V+1U**
- **D. Adjiashvili**

**401-3901-00L**

**Linear & Combinatorial Optimization**

- **W** 11 credits
- **4V+2U**
- **R. Zenklusen**
Content

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature


Prerequisites / notice

Solid background in linear algebra.

Fostered competencies

<table>
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636-0007-00L

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Objective

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Content

- Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

- We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

Lecture notes

http://www.csb.ethz.ch/education/lectures.html

Literature


401-3055-64L

Abstract

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously related on related problems.
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to
other areas. The topics covered in the class will include (but are not limited to):

Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvales of graphs and their application, the

The course website can be found at


Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

Signal Processing and Machine Learning

The core courses and specialisation courses below are a selection for students who wish to specialise in the area of "Signal Processing and Machine Learning", see https://www.ee.ethz.ch/studies/main-master/areas-of-specialisation.html.

The individual study plan is subject to the tutor's approval.

Core Courses

These core courses are particularly recommended for the field of "Signal Processing and Machine Learning".

You may choose core courses form other fields in agreement with your tutor.

A minimum of 24 credits must be obtained from core courses during the MSc EEIT.

Foundation Core Courses

Fundamentals at bachelor level, for master students who need to strengthen or refresh their background in the area.

Number Title Type ECTS Hours Lecturers
227-0101-00L Discrete-Time and Statistical Signal Processing W 6 credits 4G H.-A. Loeliger

Abstract The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content 1. Discrete-time linear systems and filters:
state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Introduction to Estimation and Machine Learning W 6 credits 4G H.-A. Loeliger

Abstract Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

Objective Students master the basic mathematical concepts and algorithms of estimation and machine learning.

Content Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more

Lecture notes Lecture notes will be handed out as the course progresses.

Prerequisites / notice solid basics in linear algebra and probability theory

Advanced Core Courses

Advanced core courses bring students to gain in-depth knowledge of the chosen specialization. They are MSc level only.

Number Title Type ECTS Hours Lecturers
227-0423-00L Neural Network Theory W 4 credits 2V+1U H. Bölcskei

Abstract The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.
Content
1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Lecture notes
Detailed lecture notes are available on the course web page
https://www.mins.ee.ethz.ch/teaching/nnt/

Prerequisites / notice
This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

227-0447-00L Image Analysis and Computer Vision W 6 credits 3V+1U E. Konukoglu, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis.

The main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
What is data? Bayesian Learning Computational learning theory

Supervised learning:
Ensembles: Bagging and Boosting Max Margin methods Neural networks

Unsupervised learning:
Dimensionality reduction techniques Clustering Mixture Models Non-parametric density estimation Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature


Introduction to various mathematical aspects of Data Science.

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>CP Credits</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-4944-20L</td>
<td>Mathematics of Data Science</td>
<td>8</td>
<td>4G</td>
<td>A. Bandeira</td>
</tr>
</tbody>
</table>

Abstract

Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

Objective

Introduction to various mathematical aspects of Data Science.

Lecture notes


Prerequisites / notice

The main mathematical tools used will be Probability and Linear Algebra, and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity--including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

>>> Specialisation Courses

These specialisation courses are particularly recommended for the area of "Signal Processing and Machine Learning", but you are free to choose courses from any other field in agreement with your tutor.

A minimum of 40 credits must be obtained from specialisation courses during the MSc EEIT.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>F. K. Gürkaynak, L. Benini</td>
</tr>
</tbody>
</table>

Abstract

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.
### Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
  - SystemVerilog
    - Register Transfer Level (RTL) synthesis and its limitations.
    - Building blocks of digital VLSI circuits.
    - Functional verification techniques and their limitations.
    - Modular and largely reusable testbenches.
    - Assertion-based verification.
    - Synchronous versus asynchronous circuits.
    - The case for synchronous circuits.
    - Periodic events and the Anceau diagram.
    - Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

#### Lecture notes
Textbook and all further documents in English.

#### Literature

#### Prerequisites / notice
Prerequisites:
- Basics of digital circuits.

Examination:
- In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/

### 227-0155-00L Machine Learning on Microcontrollers

**Registration in this class requires the permission of the instructors. Class size will be limited to 25.**

**Preference is given to students in the MSc EEIT.**

#### Abstract
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V).

#### Objective
Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras,…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.

#### Content
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:
- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

#### Lecture notes
Script and exercise sheets. Books will be suggested during the course.

#### Prerequisites / notice
Prerequisites:
- C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

### 227-0121-00L Communication Systems

**Does not take place this semester.**

#### Abstract
Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

#### Objective
Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

#### Content
Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

#### Lecture notes
Lecture Slides

#### Literature
**227-0225-00L**

**Linear System Theory**

**W** 6 credits 5G J. Lygeros, A. Tsiamas

**Abstract**

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

**Objective**

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Lecture notes**

Available on the course Moodle platform.

**Prerequisites / notice**

Sufficient mathematical maturity, in particular in linear algebra, analysis.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Technics and Technologies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

**227-0417-00L**

**Information Theory I**

**W** 6 credits 4G A. Lapidoth

**Abstract**

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

**Objective**

The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

**Content**

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

**Literature**

T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

**227-0421-00L**

**Deep Learning in Artificial and Biological Neuronal Networks**

**W** 4 credits 3G B. Grewe

**Abstract**

Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think different about state-of-the-art ANN training methods.

**Objective**

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience.

**Content**

These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers. After this course students will be able to:

- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

**Lecture notes**

The lecture slides will be provided as a PDF after each lecture.

**Prerequisites / notice**

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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</tbody>
</table>

**227-0477-00L**

**Acoustics I**

**W** 3 credits 2G K. Heutschi

**Abstract**

Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.

**Objective**

Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

**Content**

Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.

**Lecture notes**

yes

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1) The number of participants is limited to 120 students (MSc and PhDs).

2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 960 of 2416
Topics covered: By the end of the semester students should be able to
- Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on
  - Concepts and Theories assessed
  - Analytical Competencies not assessed
  - Problem-solving assessed
  - Communication assessed
  - Creative Thinking not assessed
  - Critical Thinking assessed
  - Self-direction and Self-management assessed

263-5210-00L Probabilistic Artificial Intelligence W 8 credits 3V+2U+2A A. Krause

Abstract This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

Objective How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit “intelligent” behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice Solid basic knowledge in statistics, algorithms and programming. The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

263-5255-00L Foundations of Reinforcement Learning W 5 credits 2V+2A N. He

Abstract Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on the theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control.

Objective This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Prerequisites / notice Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

263-5300-00L Guarantees for Machine Learning W 7 credits 3V+1U+2A F. Yang, A. Sanyal

Abstract This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

Objective By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Assessed

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Conceptual and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Critical Thinking</td>
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<tr>
<td>Assessed</td>
<td>Assessed</td>
<td>Assessed</td>
<td>Assessed</td>
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</tbody>
</table>

Prerequisites / notice

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Seminar 1

Fostered competencies

<table>
<thead>
<tr>
<th>401-3055-64L</th>
<th>Algebraic Methods in Combinatorics</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>B. Sudakov</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.</td>
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<td><strong>Objective</strong></td>
<td>The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools. One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure, one maps its elements to vectors in a linear space, and shows that the set is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):</td>
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<tr>
<td><strong>Key topics include:</strong></td>
<td>Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>The course website can be found at <a href="https://moodle-app2.let.ethz.ch/course/view.php?id=15757">https://moodle-app2.let.ethz.ch/course/view.php?id=15757</a></td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Seminar 2

Fostered competencies

<table>
<thead>
<tr>
<th>401-3621-00L</th>
<th>Fundamentals of Mathematical Statistics</th>
<th>W</th>
<th>10 credits</th>
<th>4V+1U</th>
<th>S. van de Geer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The course covers the basics of inferential statistics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Seminar 3

Fostered competencies

<table>
<thead>
<tr>
<th>401-3901-00L</th>
<th>Linear &amp; Combinatorial Optimization</th>
<th>W</th>
<th>11 credits</th>
<th>4V+2U</th>
<th>R. Zenklusen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Mathematical treatment of optimization techniques for linear and combinatorial optimization problems. The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.</td>
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<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Key topics include:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Linear programming and polyhedra;</td>
<td>- Flowing and cuts;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Combinatorial optimization problems and polyhedral techniques;</td>
<td>- Equivalence between optimization and separation.</td>
<td></td>
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</tr>
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</table>

Prerequisites / notice

Students are expected to have a mathematical background and should be able to write rigorous proofs.

Autumn Semester 2022
This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.
Objective

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

Content

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Fostered competencies

<table>
<thead>
<tr>
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<th>Method-specific Competencies</th>
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<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Creative Thinking</td>
</tr>
<tr>
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<td>assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
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Abstract

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

Objective

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Content

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

Literature

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

Fostered competencies

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Abstract

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management. The course is mandatory.

Objective

Prerequisite: Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

Content

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

Objective

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Content

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

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Abstract

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Objective

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Content

12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer
Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html
Enabling Entrepreneurship: From Science to Startup

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch

Objective

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea

Abstract

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Content

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders’ agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Literature

Book
Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

Prerequisites / notice

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

Fostered competencies

Method-specific Competencies
- Media and Digital Technologies
- Project Management

Social Competencies
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility

Personal Competencies
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

Prerequisites / notice

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Abstract

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

851-0703-00L Introduction to Law

Students who have attended or will attend the lecture “Introduction to Law for Civil Engineering and Architecture” (851-0703-03L) or “Introduction to Law” (851-0708-00L), cannot register for this course unit.

Particularly suitable for students of D-ARCH, D-MAVT, D-MATL

Objective

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

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Objective

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Abstract

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of entrepreneurs. The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

The role of intellectual property in the engineering and technical sector is both a challenge and an opportunity. The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

The lecture addresses students in the fields of engineering, science and other related technical fields.

### Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1550-10L</td>
<td>Internship in Industry</td>
<td>W</td>
<td>12</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

The main objective of the 12-week internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in ongoing projects at the host institution.

### Master Studies (Programme Regulations 2008)

### Major Courses

A total of 42 CP must be achieved during the Master Programme. The individual study plan is subject to the tutor's approval.

### Communication

### Core Subjects
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

**Contents**

- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

**Literature**

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010


**Recommended Subjects**

These courses are particularly recommended for the field of "Communication":

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>227-0301-00L</td>
<td>Optical Communication Fundamentals W 6 credits 2V+1U+1P</td>
<td>J. Leuthold</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>227-0417-00L</td>
<td>Information Theory I W 6 credits 4G</td>
<td>A. Lapidoth</td>
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<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems W 6 credits 4G</td>
<td>L. Josipovic, L. Vanbever, R. Wattenhofer</td>
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</table>

**Abstract**

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements. An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

**Objective**

The entropy rate of a source, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

**Content**

- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

**Literature**

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010


**Recommended Subjects**

These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

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**Abstract**

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

**Objective**

The fundamentals of Information Theory including Shannon’s source coding and channel coding theorems

**Content**

- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
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**Literature**

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010


**Recommended Subjects**

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F. Dörfler

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high-precision arithmetic. It introduces concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback is central to the design of control systems for single input - single output and multivariable systems.

**Objective**

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Content**


**Literature**


**Prerequisites / notice**

Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

---

227-0103-00L  
**Control Systems**  
W 6 credits 2V+2U  
F. Dörfler

**Abstract**

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Objective**

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Content**


**Literature**


**Prerequisites / notice**

Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

---

227-0116-00L  
**VLSI 1: HDL Based Design for FPGAs**  
W 6 credits 5G  
F. K. Gürkaynak, L. Benini

**Abstract**

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high-performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

**Objective**

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

**Content**

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits
- Periodic events and the Aneur diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

**Lecture notes**

Textbook and all further documents in English.

**Literature**

### Prerequisites / notice

- **Prerequisites:** Basics of digital circuits.

- **Examination:** In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

- **Further details:** [https://lis-students.ee.ethz.ch/lectures/vlsi-i/](https://lis-students.ee.ethz.ch/lectures/vlsi-i/)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS Credits</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>T. Jang</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Handouts of presented slides. No script but an accompanying textbook is recommended.</td>
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</tr>
<tr>
<td><strong>Literature</strong></td>
<td>Behzad Razavi, Design of Analog CMOS Integrated Circuits (Irwin Electronics &amp; Computer Engineering) 1st or 2nd edition, McGraw-Hill Education</td>
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<tr>
<th>Course Code</th>
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<th>ECTS Credits</th>
<th>Instructor</th>
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<tr>
<td>227-0301-00L</td>
<td>Optical Communication Fundamentals</td>
<td>W</td>
<td>6</td>
<td>2V+1U+1P</td>
<td>J. Leuthold</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.</td>
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<tr>
<td><strong>Content</strong></td>
<td>* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.</td>
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<td>* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.</td>
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<td>* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.</td>
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<td></td>
<td>* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.</td>
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<td></td>
<td>* Chapter 7: Optical Amplifiers : Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Lecture notes are handed out.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Govind P. Agrawal; &quot;Fiber-Optic Communication Systems&quot;; Wiley, 2010</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Fundamentals of Electromagnetic Fields &amp; Bachelor Lectures on Physics.</td>
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<tr>
<th>Course Code</th>
<th>Title</th>
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<th>Credits</th>
<th>ECTS Credits</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>227-0423-00L</td>
<td>Neural Network Theory</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Bölcskei</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.</td>
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<tr>
<td><strong>Content</strong></td>
<td>1. Universal approximation with single- and multi-layer networks</td>
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<td>2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory</td>
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<td>3. Fundamental limits of deep neural network learning</td>
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<td>4. Geometry of decision surfaces</td>
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<td>5. Separating capacity of nonlinear decision surfaces</td>
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<td>6. Vapnik-Chervonenkis (VC) dimension</td>
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<td>7. VC dimension of neural networks</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Detailed lecture notes are available on the course web page <a href="https://www.mins.ee.ethz.ch/teaching/nnt/">https://www.mins.ee.ethz.ch/teaching/nnt/</a></td>
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<td><strong>Prerequisites / notice</strong></td>
<td>This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.</td>
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<th>Course Code</th>
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<th>ECTS Credits</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>E. Konukoglu, F. Yu</td>
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Data: 01.11.2022 12:41   Autumn Semester 2022   Page 969 of 2416
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta
conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow
view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two
groups.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during
the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and
understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using
the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators
merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given,
including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion
on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits"
complements This lecture very well in that respect. Details: https://people.ee.ethz.ch/~haschmid/asfwiki/
The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes , and a Python-
based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password
Prerequisites / notice
Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated
Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability
criteria ...) and of the main properties of linear systems is necessary.

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</table>
| Objective | Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience
through practical computer and programming exercises. |
| Content | This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep
learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image
processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is
considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then
turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear
filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic
information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific
objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based
approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets
are given. |
| Lecture notes | Course material Script, computer demonstrations, exercises and problem solutions |
| Prerequisites / notice | Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English. |
| 227-0468-00L | Analog Signal Processing and Filtering |
| Abstract | Suitable for Master Students as well as Doctoral Students. |
| Objective | This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta
conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow
view. The lecture is suitable for both analog and digital designers. |
| Lecture notes | The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the
technical content. |
| Prerequisites / notice | Details: https://people.ee.ethz.ch/~haschmid/asfwiki/ |
| Fostered competencies | | |
| Subject-specific Competencies | | |
| Concepts and Theories | assessed |
| Techniques and Technologies | assessed |
| Method-specific Competencies | | |
| Analytical Competencies | assessed |
| Decision-making | not assessed |
| Media and Digital Technologies | not assessed |
| Problem-solving | assessed |
| Project Management | not assessed |
| Social Competencies | | |
| Communication | not assessed |
| Cooperation and Teamwork | not assessed |
| Customer Orientation | not assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity | not assessed |
| Negotiation | not assessed |
| Personal Competencies | | |
| Adaptability and Flexibility | not assessed |
| Creative Thinking | not assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | not assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and Self-management | not assessed |
| 227-0477-00L | Acoustics I |
| Abstract | Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound
propagation and room acoustics of large and small enclosures. |
The course will cover topics spanning four broad themes with a focus on the first two themes:

- Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.

Content

The course will be accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Prerequisites / notice

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

Additional information

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>227-0147-10L VLSI 3: Full-Custom Digital Circuit Design</th>
<th>401-3055-64L Algebraic Methods in Combinatorics</th>
</tr>
</thead>
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<tr>
<td></td>
<td>W 6 credits</td>
<td>W 6 credits</td>
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<tr>
<td></td>
<td>2V+3U</td>
<td>2V+1U</td>
</tr>
<tr>
<td></td>
<td>B. Studer, O. Castañeda Fernández</td>
<td>B. Sudakov</td>
</tr>
</tbody>
</table>

**Abstract**

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

**Objective**

At the end of this course, you will

- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

**Literature**

- N. H. E. Weste and D. M. Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley
- VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

**Content**

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
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- Wire models and parasitics
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- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

Does not take place this semester.

**Lecture notes**

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

**Prerequisites / notice**

Students are expected to have a mathematical background and should be able to write rigorous proofs.
### Computers and Networks

#### Core Subjects

These core subjects are particularly recommended for the field of "Computers and Networks".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-2210-00L</td>
<td>Computer Architecture</td>
<td>W</td>
<td>8</td>
<td>6G+1A</td>
<td>O. Mutlu</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Computer architecture is the science &amp; art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.</td>
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<td><strong>Objective</strong></td>
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<td>We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g., graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.</td>
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<td><strong>Content</strong></td>
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<td>The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).</td>
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<td><strong>Lecture notes</strong></td>
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<td>All the materials (including lecture slides) will be provided on the course website: <a href="https://safari.ethz.ch/architecture">https://safari.ethz.ch/architecture</a></td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td>We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td>227-0575-00L</td>
<td>Advanced Topics in Communication Networks</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>L. Vanbever, R. Jacob</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover advanced topics in Internet routing and forwarding.</td>
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<td><strong>Objective</strong></td>
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<td>The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be &quot;hands-on&quot; and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.</td>
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<td><strong>Content</strong></td>
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<td>The course will cover advanced topics in Internet routing and forwarding such as:</td>
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<td>- Tunneling</td>
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<td>- Hierarchical routing</td>
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<td>- Traffic Engineering and Load Balancing</td>
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<td>- Virtual Private Networks</td>
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<td>- Quality of Service/Queueing/Scheduling</td>
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<td>- Fast Convergence</td>
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<td>- Network virtualization</td>
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<td>- Network programmability (OpenFlow, P4)</td>
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<td></td>
<td>- Network measurements</td>
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<td>The course will be divided in two main blocks. The first block (~8 weeks) will interleave classical lectures with practical exercises and labs. The second block (~8 weeks) will consist of a practical project which will be performed in small groups (~3 students). During the second block, lecture slots will be replaced by feedback sessions where students will be able to ask questions and get feedback about their project. The last week of the semester will be dedicated to student presentations and demonstrations.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Lecture notes and material will be made available before each course on the course website.</td>
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<td><strong>Literature</strong></td>
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<td>Relevant references will be made available through the course website.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Prerequisites: Communication Networks (227-0120-00L) or equivalents / good programming skills (in any language) are expected as both the exercises and the final project will involve coding.</td>
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<td><strong>Fostered competencies</strong></td>
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<td>Subject-specific Competencies</td>
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<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<tr>
<td>227-0579-00L</td>
<td>Hardware Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>K. Razavi</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td><strong>Objective</strong></td>
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<td><strong>Content</strong></td>
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<td><strong>Fostered competencies</strong></td>
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Abstract
This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.

Objective
By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:

- security problems of commodity hardware that we use everyday and how you can defend against them.
- relevant computer architecture and operating system aspects of these issues.
- hands-on techniques for performing hardware attacks.
- writing critical reviews and constructive discussions with peers on this topic.

This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.

Literature
Slides, relevant literature and manuals will be made available during the course.

Prerequisites / notice
Experience with Linux, systems programming and computer architecture.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-1414-00L</td>
<td>System Security</td>
<td>W</td>
<td>7 credits</td>
<td>2V+U+2A</td>
<td>S. Capkun, S. Shinde</td>
</tr>
<tr>
<td>263-4640-00L</td>
<td>Network Security</td>
<td>W</td>
<td>8 credits</td>
<td>2V+2U+3A</td>
<td>A. Perrig, S. Frei, M. Legner, K. Paterson</td>
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</table>

Recommended Subjects
These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

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<tr>
<th>Number</th>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 974 of 2416
227-0101-00L Discrete-Time and Statistical Signal Processing

W 6 credits 4G H.-A. Loeliger

Abstract
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content
1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.
2. The discrete Fourier transform and its use for digital filtering.
3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes
Lecture Notes

227-0103-00L Control Systems

W 6 credits 2V+2U F. Dörfler

Abstract
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content

Literature

Prerequisites / notice
Prerequisites: Signal and Systems Theory II.
MATLAB is used for signal analysis and simulation.

227-0116-00L VLSI 1: HDL Based Design for FPGAs

W 6 credits 5G F. K. Gürkaynak, L. Benini

Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Aneau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes
Textbook and all further documents in English.

Literature
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has

2V + 1U + 2A

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the

Security of Wireless Networks

Familiarize students with main architectural principles and concepts of embedded control systems.

W

An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this

Lecture notes

Content

2V + 1U

Prerequisites / notice

Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website

http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

Core Subjects

These core subjects are particularly recommended for the field of “Electronics and Photonics”.

Number Title Type ECTS Hours Lecturers

Autumn Semester 2022

Page 977 of 2416
227-0146-00L Analog-to-Digital Converters

**Abstract**

This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.

**Objective**

Data conversion systems are substantial sub-parts of many electronic systems, e.g. the audio conversion system of a home-cinema systems or the base-band front-end of a wireless modem. Data conversion systems usually determine the performance of the overall system in terms of dynamic range and linearity. The student will learn to understand the basic principles behind data conversion and be introduced to the different methods and circuit architectures to implement such a conversion. The conversion methods such as successive approximation or algorithmic conversion are explained with their principle of operation accompanied with the appropriate mathematical calculations, including the effects of non-idealities in some cases. After successful completion of the course the student should understand the concept of an ideal ADC, know all major converter architectures, their principle of operation and what governs their performance.

**Content**

- Introduction: information representation and communication; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; tradeoffs among key parameters; ADC taxonomy.
- Dual-slope & successive approximation register (SAR) converters: dual slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.
- Algorithmic & pipelined A/D converters: algorithmic conversion principle; sample & hold stage; pipe-lined converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.
- Performance metrics and non-linearity: ideal ADC; offset, gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.
- Flash, folding an interpolating analog-to-digital converters; flash ADC principle, thermometer to binary coding, sparkle correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.
- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-order delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.

**Lecture notes**

Slides are available online under https://lis-students.ee.ethz.ch/lectures/analog-to-digital-converters/

**Literature**

- M. Gustavsson et. al., CMOS Data Converters for Communications, Springer, 2010

**Prerequisites / notice**

It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.

227-0147-10L VLSI 3: Full-Custom Digital Circuit Design

**Abstract**

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

**Objective**

At the end of this course, you will
- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

**Content**

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:
- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

**Literature**

N. H. E. Weste and D. M. Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

**Prerequisites / notice**

VLSI 3 can be taken in parallel with "VLSI 1: HDL-based design for FPGAs" and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

**Fostered competencies**

- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies

227-0301-00L Optical Communication Fundamentals

**Abstract**

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

**Objective**

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.
Chapter 1: The Wave Equations in Nonlinear Optics

Nonlinear Optics deals with the interaction of light with matter. I.e. the response of insulators, metals, semiconductors or metamaterials to light and the mathematical framework (classical and quantum mechanical) to describe the phenomena. It is the goal to understand phenomena such as the refractive index, the electro-optic effect, rectification, harmonic generation, FWM, soliton propagation,...

Prerequisites / notice
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

Lecture notes
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.

Chapter 7: Optical Amplifiers - Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Prerequisites / notice


Prerequisites / notice


Prerequisites / notice

Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

Prerequisites / notice

Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

Prerequisites / notice

Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

Prerequisites / notice

Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Prerequisites / notice

Chapter 8: Nonlinear Effects in Media with Gain

Prerequisites / notice

Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator

Prerequisites / notice

Chapter 4: Second Harmonic Generation

Prerequisites / notice

Chapter 3: The Nonlinear Optical Susceptibility - Classical and Quantummechanical Derivations

Prerequisites / notice

Chapter 2: Acousto-Optic Effect

Prerequisites / notice

Chapter 1: The Nonlinear Optical Susceptibility

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.

Chapter 7: Optical Amplifiers - Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.

Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.

Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.

Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.


Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.


Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.

Chapter 1: The Wave Equations in Nonlinear Optics

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice
Partial: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Recommended Subjects
These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0121-00L</td>
<td>Communication Systems</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>to be announced</td>
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<td>Does not take place this semester.</td>
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<tr>
<td>Abstract</td>
<td>Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet</td>
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<tr>
<td>Objective</td>
<td>Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems</td>
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<tr>
<td>Content</td>
<td>Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.</td>
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<td>Lecture notes</td>
<td>The application of the basic methods will be extensively explained using existing and future wireless and wired systems.</td>
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<tr>
<td>Literature</td>
<td>Lecture Slides</td>
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<tr>
<td>227-0155-00L</td>
<td>Machine Learning on Microcontrollers</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>M. Magno, L. Benini</td>
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<td>Registration in this class requires the permission of the instructors. Class size will be limited to 25. Preference is given to students in the MSC EEIT.</td>
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<tr>
<td>Abstract</td>
<td>Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are incorporating ML, becoming increasingly “smart”. This lecture gives an overview of ML methods and algorithms to process and extract useful near-sensor information in end-nodes of the “internet-of-things”, using low-power microcontrollers/processors (ARM-Cortex-M; RISC-V)</td>
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<tr>
<td>Objective</td>
<td>Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras,…). The main objective is to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power microcontrollers.</td>
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<tr>
<td>Content</td>
<td>The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:</td>
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<td></td>
<td>- Sensors and sensor data acquisition with low power embedded systems</td>
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<td></td>
<td>- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)</td>
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<td></td>
<td>- Low-power embedded systems and their architecture. Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.</td>
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<td></td>
<td>- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.</td>
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<td>The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.</td>
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<td>Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.</td>
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<tr>
<td>Lecture notes</td>
<td>Script and exercise sheets. Books will be suggested during the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable</td>
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<td>227-0157-00L</td>
<td>Semiconductor Devices: Physical Bases and Simulation</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. Schenk, C. I. Roman</td>
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<tr>
<td>Abstract</td>
<td>The course addresses the physical principles of modern semiconductor devices and the foundations of their modeling and numerical simulation. Necessary basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.</td>
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The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided.

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.


The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.


The script (in book style) is sufficient. Further reading will be recommended in the lecture.


227-0166-00L Analog Integrated Circuits W 6 credits 2V+2U T. Jang

Abstract
This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

Objective
Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Content
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc: Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Literature

227-0377-10L Physics of Failure and Reliability of Electronic Devices and Systems W 3 credits 2V I. Shorubalko, M. Held

Objective
Proving the understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

Content
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

Literature

227-0468-00L Analog Signal Processing and Filtering W 6 credits 2V+2U H. Schmid

Objective
Suitable for Master Students as well as Doctoral Students.

This lecture provides a wide overview on analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements This lecture very well in that respect.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes , and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.


Prerequisites
Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.
### 227-0615-00L Simulation of Photovoltaic Devices - From Materials to W Modules

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

**Abstract**
The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation of photovoltaic systems. Further, students shall be introduced to the simulation of entire solar modules and large scale photovoltaic systems.

**Objective**
Get an overview over the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to predict the performance of solar cells and modules.

**Content**
- Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)

**Literature**
- M. A. Green, „Solar cells: operating principles, technology, and system applications“, Prentice Hall, 1982.

**Prerequisites / notice**
Undergraduate physics, mathematics, semiconductor devices

### 227-0617-00L Solar Cells

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Social Competencies: Communication
- Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

**Abstract**
Physics, technology, characteristics and applications of photovoltaic solar cells. Introduction to solar radiation, physics, technology, characteristics and applications of photovoltaic solar cells and systems.

**Objective**
Solar radiation characteristics, physical mechanisms for the light to electrical power conversion, properties of semiconductors for solar cells, processing and properties of conventional Si and GaAs based solar cells, technology and physics of thin film solar cells based on compound semiconductors, other solar cells including organic and dye sensitized cells, problems and new developments for power generation in space, interconnection of cells and solar module design, measurement techniques, system design of photovoltaic plants, system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples.

**Content**
- Lecture notes
- Prerequisites: Basic knowledge of semiconductor properties.
The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.

The seminar aims at instructing graduate and PhD students in the basics of presentation techniques, i.e. "how to give a professional talk".

The seminar topics' are simulation of nanoelectronic processes and devices, and the optical as well as electronic simulation of power semiconductor devices with special attention to MOS and IGBT. The starting part on technology provides an overview on the main device families and includes a review and a brief survey of the most relevant application-oriented aspects of the device physics, thermal management, and packaging. The second section deals with the basic experimental characterization techniques for the definition of the semiconductor material properties, electrical characteristics, safe operating area, and junction temperature of the devices. The following section introduces the basic principles for electrical, thermal, and electro-thermal simulation of power electronics devices by Technology Computed Aided Design (TCAD) and compact modeling. Finally, procedures are methods are presented to implement efficient built-in reliability programs targeted on power semiconductors. They include failure physics, dedicated failure analysis techniques, accelerated testing, defect screening, and lifetime modeling.

During the laboratory activities, selections of the experimental techniques presented in the lecture are demonstrated on the basis of realistic examples. Furthermore, schematic power devices will be simulated by the students with advanced TCAD tools and circuit simulators.

Lecture notes
Handouts to the lecture (approx. 250 pp.)

Literature
- Eiichio Ohno: "Introduction to Power Electronics"
- B. Muri et al.: “Smart Power ICs"
- B. J. Baliga: "Physics Modern Power Devices"
- S. K. Ghani: "Semiconductor Power Devices"

Charge Transport in Energy Conversion and Storage Devices

The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolyzers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.

By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolyzers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

Lecture notes
Handouts to the lecture (approx. 250 pp.)

Prerequisites
Be motivated to change the world to renewable energies! Elements of calculus will be reviewed at the beginning of the course, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition.

Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite. Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students. A visit to a solar cell or battery fab will be organized during the semester if the epidemiological situation permits.

Electromagnetic Precision Measurements and Opto-Mechanics

The measurement process is at the heart of both science and engineering. Electromagnetic fields have proven to be particularly powerful probes. This course provides the basic knowledge necessary to understand current state-of-the-art optomechanical measurement systems operating at the precision limits set by the laws of quantum mechanics.

The goal of this course is to understand the fundamental limitations of measurement systems relying on electromagnetic fields.

Prerequisites
1. Electrodynamics
2. Physics 1.2
3. Introduction to quantum mechanics

Integrated Systems Seminar

In the "Fachseminar II" the students learn to communicate topics, ideas or problems of scientific research by listening to more experienced authors and by presenting scientific work in a conference-like situation for a specific audience.

The seminar aims at instructing graduate and PhD students in the basics of presentation techniques, i.e. "how to give a professional talk". Attendees have the possibility to become acquainted with a current topic by a literature study, and to present the results thereof in a 20 minutes talk in English. The participation at the seminar gives also an overview on current problems in modern nano- and opto-electronics.

The seminar topics' are simulation of nano electronic processes and devices, and the optical as well as electronic simulation of optoelectronic devices as lasers, photodiodes, etc.

Prerequisites
The students learn how to find the right literature for a certain topic quickly, as well as how to prepare a talk for a scientific conference, i.e. presentation techniques.

Battery Integration Engineering

Students are required to have attended one of the following courses:
- 227-0664-00L Technology and Policy of Electrical Energy Storage
- 529-0440-00L Physical Electrochemistry and Electrocatalysis
- 529-0191-01L Renewable Energy Technologies II,
Abstract
Batteries enable sustainable mobility, renewable power integration, various power grid services, and residential energy storage. Linked with
low cost PV, Li-ion batteries are positioned to shift the 19th-century centralized power grid into a 21st-century distributed one. As with
battery integration, this course combines understanding of electrochemistry, heat & mass transfer, device engineering.

Objective
The learning objectives are:
- Apply critical thinking on advancements in battery integration engineering. Assessment reflects this objective and is based on review of a
  scientific paper, with mark weighting of 10 / 25 / 65 for a proposal / oral presentation / final report, respectively.
- Design battery system concepts for various applications in the modern power system and sustainable mobility, with a deep focus on
  replacing diesel buses with electric buses combined with charging infrastructure.
- Critically assess progresses in battery integration engineering: from material science of novel battery technologies to battery system
design.
- Apply "lessons learned" from the history of batteries to assess progress in battery technology.
- Apply experimental and physical concepts to develop battery models in order to predict lifetime.
- Battery systems for the modern power grid and sustainable mobility.
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.
- Sustainability and life cycle analysis of battery system innovations.

Content
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.
- Sustainability and life cycle analysis of battery system innovations.

Prerequisites / notice
Limited to 30 Students. Priority given to Electrical and Mechanical Engineering students.

Exception given for PhD students

151-0605-00L Electronics and Nanosystems
- 529-0659-00L Electrochemistry
- 529-0191-01L Renewable Energy Technologies II, Energy Storage and Conversion
- 529-0659-00L Electrochemistry

Abstract
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards
complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed
assembly of 2D and 3D structures.

Objective
Familiarize students with basic science and engineering principles governing the nano domain.
Content

The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum

From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.

Literature


Prerequisites / notice

Lectures and Mini-Review presentations: Thursday 10-13

Homework: Mini-Review (compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented orally and as a written paper.

151-0620-00L Embedded MEMS Lab

Abstract

Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access

Objective

Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

Content

With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:

- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Lecture notes / Literature

A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

The document provides sufficient information for the participants to successfully participate in the course.

Prerequisites / notice

Participating students are required to attend all scheduled lectures and meetings of the course.

For safety and efficiency reasons the number of participating students is limited. We restrict to grant access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"

Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Kourmoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

Priority 4: all other students (PhD, bachelor, master) with a background in silicon or Microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation

Abstract

The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

Objective

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.
401-3055-64L  Algebraic Methods in Combinatorics  W  6 credits  2V+1U  B. Sudakov

**Abstract**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, explicit constructions of Ramsey graphs and many others.
- Students are expected to have a mathematical background and should be able to write rigorous proofs.
- The course can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

**Literature**

- Slides will be available on the Moodle page
- Readings will be available on the Moodle page
- The course content and methods are designed for students with some background in management and/or economics

**Prerequisites / notice**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
  - Critical Thinking
- Personal Competencies
  - assessed

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### Energy and Power Electronics

#### Core Subjects

*These core subjects are particularly recommended for the field of “Energy and Power Electronics”.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0117-00L</td>
<td>High Voltage Engineering</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>C. Franck, U. Straumann</td>
</tr>
</tbody>
</table>

**Abstract**
High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, ..., High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages.

**Objective**
The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify of weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

**Content**
- discussion of the field equations relevant for high voltage engineering,
- analytical and numerical solutions/solving of this equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components
Lecture notes
Lecture Slides

Literature

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Literature

Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Prerequisites: Introductory course on power electronics is recommended.

Lecture notes
Lecture notes and associated exercises including correct answers.

Prerequisites / notice
Lecture notes: Introductory course on power electronics is recommended.

ECTS
4G

- The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

- The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis tools in steady and dynamic states.

- The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes
Lecture notes

227-0247-00L Power Electronic Systems I W 6 credits 4G J. Biela, F. Krismer

Abstract
Basics of the switching behavior, gate drive and snubber circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications.

Objective
Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

Content
Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

Lecture notes
Lecture notes

Prerequisites / notice
Lecture notes: Introductory course on power electronics is recommended.

227-0526-00L Power System Analysis W 6 credits 4G G. Hug

Abstract
The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Objective
The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis tools in steady and dynamic states.

Content
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes
Lecture notes

Recommended Subjects
These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number
227-0101-00L

Title
Discrete-Time and Statistical Signal Processing

Type
W

ECTS
6 credits

Hours
4G

Lecturers
H.-A. Loeliger

Abstract
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

Objective
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.

Content
1. Discrete-time linear systems and filters:
   - state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective:
   - probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes
Lecture Notes
The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts. The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

Lecture notes: Lecture Slides

Literature:


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### Fundamentals of Electric Machines

**W** 6 credits 4G

**D. Bortis, R. Bossard**

**Abstract**

This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

**Content**

- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

**Lecture notes**

Lecture notes and associated exercises including correct answers

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### Communication Systems

**W** 6 credits 4G

**to be announced**

Does not take place this semester.

**Abstract**

Information Theory, Signal Space Analysis, Baseband Transmission, Passband Transmission, Example und Channel, Data Link Layer, MAC, Example Layer 2, Layer 3, Internet

**Objective**

Introduction into the fundamentals of digital communication systems. Selected examples on the application of the fundamental principles in existing and upcoming communication systems

**Content**

Covered are the lower three layer of the OSI reference model: the physical, the data link, and the network layer. The basic terms of information theory are introduced. After this, we focus on the methods for the point to point communication, which may be addressed elegantly and coherently in the signal space. Methods for error detection and correction as well as protocols for the retransmission of perturbed data will be covered. Also the medium access for systems with shared medium will be discussed. Finally, algorithms for routing and flow control will be treated.

The application of the basic methods will be extensively explained using existing and future wireless and wired systems.

**Lecture notes**

Lecture Slides

**Literature**

The student should learn the fundamentals of the electromagnetic, thermal, mechanical, and coupled fields simulations necessary for multiphysics simulations for power systems.

**Objective**

The goals of this course are a) understanding the fundamentals of the electromagnetic, thermal, mechanical, and coupled field simulations and b) performing effective simulations of primary equipment of electric power systems. The course is understood complementary to 227-0537-00L “Technology of Electric Power System Components”, but can also be taken separately.

After completing the course the student should be able to properly and efficiently use the software to simulate practical design problems and to understand and interpret the obtained results.

**Content**

1. Electromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
   a. Short review of the governing equations
   b. Boundary conditions
   c. Initial conditions
   d. Linear and nonlinear material properties
   e. Coupled fields (electro-mechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgears (GIS)
   f. Electromagnetic compatibility (EMC)

**Prerequisites / notice**

Dozent: Dr. Markus Meyer, Ermakamitik GmbH

**Lecture notes**

Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td></td>
<td>assessed</td>
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<tr>
<td>Analytical Competencies</td>
<td></td>
<td>assessed</td>
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<tr>
<td>Critical Thinking</td>
<td></td>
<td>assessed</td>
</tr>
</tbody>
</table>

**Data: 01.11.2022 12:41  Autumn Semester 2022  Page 989 of 2416**
Complete design process: from given specifications to a complete power electronic system. Selection and / or design of suitable passive power components: specific properties, parasitic components, tolerances, high frequency losses, thermal considerations, reliability. Static and dynamic characteristics of power semiconductors. Optimized design of the EMI filter. Thermal characterization of the converter, optimized heat sink design. Additional circuitry: gate driver, measurement, control. Converter start up: typical sequence of events, circuitry required. Overall system optimization: identifying couplings between different components of the considered power electronic system, optimization targets and issues.

Prerequisites / notice
Prerequisites: Introductory course on power electronics.

**227-0617-00L** Solar Cells

**Abstract**
Physics, technology, characteristics and applications of photovoltaic solar cells.

**Objective**
Introduction to solar radiation, physics, technology, characteristics and applications of photovoltaic solar cells and systems. Solar radiation characteristics, physical mechanisms for the light to electrical power conversion, properties of semiconductors for solar cells, processing and properties of conventional Si and GaAs based solar cells, technology and physics of thin film solar cells based on compound semiconductors, other solar cells including organic and dye sensitized cells, problems and new developments for power generation in space, interconnection of cells and solar module design, measurement techniques, system design of photovoltaic plants, system components such as inverters and controllers, engineering procedures with software demonstration, integration in buildings and other specific examples.

**Prerequisites / notice**
Prerequisites: Introductory course on power electronics.

**227-0618-00L** Modeling, Characterization and Reliability of Power Semiconductors

**Abstract**
This lecture provides theoretical and experimental knowledge on the techniques for the characterization and numerical modeling of power semiconductors, as well as on the related built-in reliability strategies.

**Objective**
The students shall get acquainted with the most important concepts and techniques for characterization, numerical modeling and built-in reliability of modern power semiconductor devices. This knowledge is intended to provide the future engineer with the theoretical background and tools for the design of dependable power devices and systems.

**Content**
This lecture consists of a theoretical part (50%) and of laboratory exercises and demonstrations (50%).

**Prerequisites / notice**
Prerequisites: Basic knowledge of semiconductor properties.

**227-0619-00L** Charge Transport in Energy Conversion and Storage Devices

**Abstract**
The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolysers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage, physics, materials sciences, and chemistry.

**Objective**
By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolysers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

**Prerequisites / notice**
Be motivated to change the world to renewable energies! Elements of calculus will be reviewed at the beginning of the course, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite. Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students. A visit to a solar cell or battery fab will be organized during the semester if the epidemiological situation permits.

**227-0697-00L** Industrial Process Control

**Abstract**
Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing. General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends.

**Objective**
Introduction to process automation: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries. Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry. Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text); PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision, and diagnosis.

**Prerequisites / notice**
Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 990 of 2416
Lecture notes
Slides will be available as .PDF documents, see “Learning materials” (for registered students only)

Literature
References will be given at the end of individual lectures.

Prerequisites / notice
Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

| 227-0731-00L | Power Market I - Portfolio and Risk Management | W | 6 credits | 4G | D. Reichelt, G. A. Koeppe | Abstract |
|-------------|-----------------------------------------------|---|-----------|---|------------------------|
|             | Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model. | |
| Objective   | Knlowedge on the worldwide liberalisation of electricity markets, pan-european power trading and the role of power exchanges. Understand financial products (derivatives) based on power. Management of a portfolio containing physical production, contracts and derivatives. Evaluate trading and hedging strategies. Apply methods and tools of risk management. | |
| Content     | 1. Pan-European power market and trading | |
|             | 1.1. Power trading | |
|             | 1.2. Development of the European power markets | |
|             | 1.3. Energy economics | |
|             | 1.4. Spot and OTC trading | |
|             | 1.5. European energy exchange EEX | |
|             | 2. Market model | |
|             | 2.1. Market place and organisation | |
|             | 2.2. Balance groups / balancing energy | |
|             | 2.3. Ancillary services | |
|             | 2.4. Market for ancillary services | |
|             | 2.5. Cross-border trading | |
|             | 2.6. Capacity auctions | |
|             | 3. Portfolio and Risk management | |
|             | 3.1. Portfolio management 1 (introduction) | |
|             | 3.2. Forward and futures contracts | |
|             | 3.3. Risk management 1 (m2m, VaR, hpc, volatility, cVaR) | |
|             | 3.4. Risk management 2 (PaR) | |
|             | 3.5. Contract valuation (HPFC) | |
|             | 3.6. Portfolio management 2 | |
|             | 2.8. Risk Management 3 (enterprise wide) | |
|             | 4. Energy & Finance I | |
|             | 4.1. Options 1 basics | |
|             | 4.2. Options 2 hedging with options | |
|             | 4.3. Introduction to derivatives (swaps, cap, floor, collar) | |
|             | 4.4. Financial modelling of physical assets | |
|             | 4.5. Trading and hydro power | |
|             | 4.6. Incentive regulation | |

Lecture notes
Handouts of the lecture

Prerequisites / notice
1 excursion per semester, 2 case studies, guest speakers for specific topics.

Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

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### Systems and Control

#### Core Subjects

These core subjects are particularly recommended for the field of "Systems and Control".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0225-00L</td>
<td>Linear System Theory</td>
<td>W</td>
<td>6</td>
<td>5G</td>
<td>J. Lygeros, A. Tsiamis</td>
</tr>
<tr>
<td>Abstract</td>
<td>The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of linear control systems.</td>
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<tr>
<td>Objective</td>
<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.</td>
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<tr>
<td>Content</td>
<td>- Proof techniques and practices.</td>
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<td></td>
<td>- Linear spaces, normed linear spaces and Hilbert spaces.</td>
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<td></td>
<td>- Ordinary differential equations, existence and uniqueness of solutions.</td>
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<td>- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.</td>
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<td></td>
<td>- Controllability and observability, duality. Time invariant systems treated as a special case.</td>
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<td></td>
<td>- Stability and stabilization, observers, state and output feedback, separation principle.</td>
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<tr>
<td>Lecture notes</td>
<td>Available on the course Moodle platform.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Sufficient mathematical maturity, in particular in linear algebra, analysis.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<td></td>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
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<td></td>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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</tbody>
</table>

| 227-0697-00L  | Industrial Process Control     | W   | 4    | 3G    | A. Horch, L. Dominguez Palomeque |
| Abstract      | Introduction to industrial automation systems with application to the process industry, power generation as well as discrete manufacturing. General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends. | |
| Objective     | General understanding of industrial automation systems in different industries. Purpose, architecture, technologies, application examples, current and future trends. | |
Introduction to discrete event systems: system architecture, data handling, communication (fieldbuses), process visualization, and engineering. Differences and characteristics of discrete and process industries.

Analysis and design of open loop control problems: discrete automata, finite state machines, decision tables, and petri-nets. Practical analysis and design of closed-loop control for the process industry.

Automation Engineering: Application programming in IEC 61131-3 (ladder diagrams, function blocks, sequence control, structured text); PLC programming and simulation, process visualization and operation; engineering integration from sensors, cabling, topology design, function, visualization, diagnosis, to documentation; Industry standards (e.g. OPC, Profibus); Ergonomic design, safety (IEC61508) and availability, supervision and diagnosis.

Automation standards: Communication, Architecture, Engineering, dependable systems, functional safety, automation security.

Extensive practical examples from different process industries, power generation, gas compressor control, and automotive manufacturing.

Prerequisites / notice
Exercises: Tuesday 15-16

Practical exercises will illustrate some topics, e.g. some control software coding using industry standard programming tools based on IEC61131-3.

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea

Abstract
Introduction to Dynamic Programming and Optimal Control.

Objective
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature

Prerequisites / notice
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Recommended Subjects
These courses are recommended, but you are free to choose courses from any other special field. Please consult your tutor.

Number Title Type ECTS Hours Lecturers
227-0102-00L Discrete Event Systems W 6 credits 4G L. Josipovic, L. Vanbever, R. Wattenhofer

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes
[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitsrechnung und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser.
227-0447-00L  Image Analysis and Computer Vision  W  6 credits  3V+1U  E. Konukoglu, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Prerequisites:
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

227-0526-00L  Power System Analysis  W  6 credits  4G  G. Hug

Abstract
The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Objective
The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis tools in steady and dynamic states.

Content
The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

Lecture notes
Lecture notes.

227-0689-00L  System Identification  W  4 credits  2V+1U  R. Smith

Abstract
Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data.

Objective
To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Content
Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Closed-loop identification strategies. Trade-off between controller performance and information available for identification.


Additional papers will be available via the course Moodle.

Prerequisites / notice
Control systems (227-0216-00L) or equivalent.

227-0945-00L  Cell and Molecular Biology for Engineers I  W  3 credits  2G  to be announced

Abstract
Does not take place this semester.

The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 993 of 2416

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication.

These written documents will be graded and count as 40% for the final grade.

Lecture notes
Scripts of all lectures will be available.

Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincaré maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.
### 151-0601-00L  
**Theory of Robotics and Mechatronics**  
W        4 credits  3G  to be announced  

**Abstract**  
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**  
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**  
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**  
available.

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### 151-0563-01L  
**Dynamic Programming and Optimal Control**  
W        4 credits  2V+1U  R. D’Andrea  

**Abstract**  
Introduction to Dynamic Programming and Optimal Control.

**Objective**  
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

**Content**  
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

**Literature**  

**Prerequisites / notice**  
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

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### 151-9905-00L  
**Applied Compositional Thinking for Engineers II**  
W        4 credits  3G  A. Censi, J. Lorand  

**Abstract**  
This course is an introduction to advanced topics in Applied Category Theory focused on the needs of applications. The course favors a computational, constructive, and compositional approach targeted to applications in engineering. Applied Compositional Thinking for Engineers is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

**Objective**  
Category theory will just be the means towards this end. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.

**Content**  
The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.

- Categories
- Functors
- Co-design problems
- Natural transformations
- Adjunctions
- Traced monoidal categories
- Computation:
  - From mathematical models to algorithms
  - Solving finite co-design problems
  - Monads
  - Modeling uncertainty
- Enriched category theory:
  - Profunctors
  - Enriched categories
  - Negative category theory
- Operads

**Lecture notes**  
Slides and notes will be provided.

**Literature**  

**Prerequisites / notice**  
The course is self-contained and can be taken, in principle, without ACT4E I.  

We assume this knowledge:  
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.  
2) Basic algebra (sets, posets, relations, semigroups, groups).

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in the Spring Semester are sufficiently proficient in (1) and (2).

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### 376-1219-00L  
**Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions**  
W        3 credits  2V  R. Riener, O. Lambercy  

**Abstract**  
Rehabilitation Engg is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

**Objective**  
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Content

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
- Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
- Rehabilitation and use of kinesthetic and tactile function
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature

Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice

Introduction to Mathematical Optimization
W 5 credits 2V+1U D. Adjiashvili

Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
### Analytical Competencies

The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

**Content**

Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

**Literature**

Information about relevant literature will be given in the lecture.

**Prerequisites / notice**

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

### Linear & Combinatorial Optimization

**Abstract**

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Solid background in linear algebra.

### Computational Systems Biology

**Abstract**

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modelling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

**Objective**

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

**Content**

Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.

We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

**Lecture notes**

http://www.csb.ethz.ch/education/lectures.html

**Literature**

Objective

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments
- Spaces of polynomials and tensor product methods
- Eigenvalues of graphs and their application
- The Combinatorial Nullstellensatz and the Chevalley-Warning theorem
- Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at [https://moodle-app2.let.ethz.ch/course/view.php?id=15757](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice

Students are expected to have a mathematical background and should be able to write rigorous proofs.
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. The first interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

The course language is English.

### Content

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models

- Non-parametric density estimation

### Lecture notes

Course material, Script, computer demonstrations, exercises and problem solutions

### Prerequisites

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

The course language is English.

### Literature


### Prerequisites

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### Advanced Machine Learning

<table>
<thead>
<tr>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
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### Discrete-Time and Statistical Signal Processing

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<th>Number</th>
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<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes, elements of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.
1. Discrete-time linear systems and filters: 
state-space realizations, z-transform and spectrum, 
decimation and interpolation, digital filter design, 
stable realizations and robust inversion.

2. The discrete Fourier transform and its use for digital filtering.

3. The statistical perspective: 
probability, random variables, discrete-time stochastic processes; 
detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; 
Wiener filter, LMS adaptive filter, Viterbi algorithm.

Lecture notes

227-0116-00L VLSI 1: HDL Based Design for FPGAs W 6 credits 5G F. K. Gürkaynak, L. Benini
Abstract
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high 
performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and 
avtomatic synthesis for producing industrial-quality circuits.

Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable 
Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from 
architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected 
with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality 
VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic 
Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

Lecture notes
Textbook and all further documents in English.

Literature

Prerequisites / notice
Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/

227-0155-00L Machine Learning on Microcontrollers W 6 credits 4G M. Magno, L. Benini
Registration in this class requires the permission of the instructors. Class size will be limited to 25. Preference is given to students in the MSC EEIT.
Abstract
Machine Learning (ML) and artificial intelligence are pervading the digital society. Today, even low power embedded systems are 
incorporating ML, becoming increasingly "smart". This lecture gives an overview of ML methods and algorithms to process and extract 
useful near-sensor information in end-nodes of the "internet-of-things", using low-power microcontrollers/processors (ARM-Cortex-M; 
RISC-V).

Objective
Learn how to Process data from sensors and how to extract useful information with low power microprocessors using ML techniques. We 
will analyze data coming from real low-power sensors (accelerometers, microphones, ExG bio-signals, cameras...). The main objective is 
to study in details how Machine Learning algorithms can be adapted to the performance constraints and limited resources of low-power 
microcontrollers.
The final goal of the course is a deep understanding of machine learning and its practical implementation on single- and multi-core microcontrollers, coupled with performance and energy efficiency analysis and optimization. The main topics of the course include:

- Sensors and sensor data acquisition with low power embedded systems
- Machine Learning: Overview of supervised and unsupervised learning and in particular supervised learning (Bayes Decision Theory, Decision Trees, Random Forests, kNN-Methods, Support Vector Machines, Convolutional Networks and Deep Learning)
- Low-power embedded systems and their architecture, Low Power microcontrollers (ARM-Cortex M) and RISC-V-based Parallel Ultra Low Power (PULP) systems-on-chip.
- Low power smart sensor system design: hardware-software tradeoffs, analysis, and optimization. Implementation and performance evaluation of ML in battery-operated embedded systems.

The laboratory exercised will show how to address concrete design problems, like motion, gesture recognition, emotion detection, image and sound classification, using real sensors data and real MCU boards.

Presentations from Ph.D. students and the visit to the Digital Circuits and Systems Group will introduce current research topics and international research projects.

Lecture notes
Script and exercise sheets. Books will be suggested during the course.

Prerequisites / notice
Prerequisites: C language programming. Basics of Digital Signal Processing. Basics of processor and computer architecture. Some exposure to machine learning concepts is also desirable

227-0225-00L  Linear System Theory
W 6 credits 5G  J. Lygeros, A. Tsiamis

Abstract
This course is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes
Available on the course Moodle platform.

Prerequisites / notice
Sufficient mathematical maturity, in particular in linear algebra, analysis.

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Problem-solving
Personal Competencies
Creative Thinking
Critical Thinking
Integrity and Work Ethics

227-0417-00L  Information Theory I
W 6 credits 4G  A. Lapidoth

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, typical sequences, the asymptotic equipartition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content
- The entropy rate of a source. Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity.

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

227-0421-00L  Deep Learning in Artificial and Biological Neuronal Networks
W 4 credits 3G  B. Grewe

Abstract
Deep-Learning (DL) a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective
The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience.

Content
- Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world.
- However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al. 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.
**Lecture notes**
The lecture slides will be provided as a PDF after each lecture.

**Prerequisites / notice**
This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:

1) The number of participants is limited to 120 students (MSc and PhDs).

2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

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**263-0477-00L**

**Acoustics I**

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<td>2G</td>
<td>K. Heutschi</td>
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</table>

**Abstract**
Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures.

**Objective**
Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.

**Content**
Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.

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**263-5210-00L**

**Probabilistic Artificial Intelligence**

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<th>W</th>
<th>8 credits</th>
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<tr>
<td>3V+2U+2A</td>
<td>A. Krause</td>
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</tbody>
</table>

**Abstract**
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Content**
Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**
Solid basic knowledge in statistics, algorithms and programming.

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**263-5255-00L**

**Foundations of Reinforcement Learning**

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<td>2V+2A</td>
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*Does not take place this semester.*

**Number of participants limited to 190.**

*The course will be offered again in FS23.*

**Abstract**
Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control.

**Objective**
This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to:
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

**Content**
Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

**Lecture notes**
Lecture notes will be posted on Moodle.

**Literature**
Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepesvári.

**Prerequisites / notice**
Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

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**263-5300-00L**

**Guarantees for Machine Learning**

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<tr>
<td>3V+1U+2A</td>
<td>F. Yang, A. Sanyal</td>
</tr>
</tbody>
</table>

*Number of participants limited to 30.*

**Abstract**
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.
Objective

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in-person exercises, homeworks and potentially in the final project

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

Content

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”/ “Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</tbody>
</table>

401-3901-00L Linear & Combinatorial Optimization W 11 credits 4V+2U R. Zenklusen

Abstract

Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

Objective

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

Content

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Literature


Prerequisites / notice

Former course title: Mathematical Optimization.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<td>Cooperation and Teamwork</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</table>
### 401-3621-00L Fundamentals of Mathematical Statistics

**W** 10 credits 4V+1U  S. van de Geer

**Abstract**
The course covers the basics of inferential statistics.

### 401-3055-64L Algebraic Methods in Combinatorics

**W** 6 credits 2V+1U  B. Sudakov

**Does not take place this semester.**

**Abstract**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

**Content**
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Waring theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk’s conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

**Lecture notes**
The course website can be found at [https://moodle-app2.let.ethz.ch/course/view.php?id=15757](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)

**Prerequisites / notice**
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

### 401-3054-14L Probabilistic Methods in Combinatorics

**W** 6 credits 2V+1U  B. Sudakov

**Abstract**
This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

**Content**
The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

**Literature**
- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

### Subjects of General Interest

These courses are suitable for several special fields. Please consult your tutor.

#### Number  Title  Type  ECTS  Hours  Lecturers

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
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<td>227-0377-10L</td>
<td>Physics of Failure and Reliability of Electronic Devices and Systems</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>I. Shorubalo, M. Held</td>
</tr>
</tbody>
</table>

**Abstract**
Understanding the physics of failures and failure mechanisms enables reliability analysis and serves as a practical guide for electronic devices design, integration, systems development and manufacturing. The field gains additional importance in the context of managing safety, sustainability and environmental impact for continuously increasing complexity and scaling-down trends in electronics.

**Objective**
Provide an understanding of the physics of failure and reliability. Introduce the degradation and failure mechanisms, basics of failure analysis, methods and tools of reliability testing.

**Content**
Summary of reliability and failure analysis terminology; physics of failure: materials properties, physical processes and failure mechanisms; failure analysis; basics and properties of instruments; quality assurance of technical systems (introduction); introduction to stochastic processes; reliability analysis; component selection and qualification; maintainability analysis (introduction); design rules for reliability, maintainability, reliability tests (introduction).

**Lecture notes**
Comprehensive copy of transparencies

**Literature**

| 363-0790-00L | Technology Entrepreneurship                                         | W    | 2    | 2V    | F. Hacklin      |

**Abstract**
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

**Objective**
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.
Content

12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

Lecture notes
Lecture slides and case material

Visualization, Simulation and Interaction - Virtual Reality II
W 4 credits 3G A. Kunz

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.

The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained in more detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Media and Digital Technologies

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking

Didactical concept:
The course consists of lectures and exercises.

Semester Projects

Number Title Type ECTS Hours Lecturers

227-1101-00L How to Write Scientific Texts E- 0 credits U. Koch

Abstract
The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Objective
- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

Content
* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, “in this paper” paragraph, scientific part, summary, equations, figures)
* Topic 2: Structure of Scientific Presentations
* Topic 3: Citation Rules and Citation Software
* Topic 4: Guidelines for Scientific Integrity

Literature
ETH “Citation Etiquette”, see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html
ETH “Scientific Integrity”, see https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html
Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>Semester Project (Nr 1)</th>
<th>O</th>
<th>12 credits</th>
<th>20A</th>
<th>Supervisors</th>
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<td>Registration in myStudies required!</td>
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<tr>
<td>-</td>
<td>Supervisor must be a professor at D-ITET or associated, see <a href="https://ee.ethz.ch/studies/master-s-programmes/main-master/projects-and-master-thesis.html">https://ee.ethz.ch/studies/master-s-programmes/main-master/projects-and-master-thesis.html</a></td>
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<tr>
<td></td>
<td>The first semester project is compulsory for students enrolled in the MSc EEIT under the 2008 regulations and for students enrolled under the 2018 regulations.</td>
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<tr>
<td>Abstract</td>
<td>Semester projects are designed to train the students for independent scientific work. A project uses the student's technical and social skills acquired during the master's program. The semester project comprises 280 hours of work and is supervised by a professor.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Supervisor must be a professor at D-ITET or associated, see <a href="https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html">https://www.ee.ethz.ch/studies/main-master/projects-and-master-thesis.html</a></td>
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<td>The second semester project is compulsory for students enrolled in the MSc EEIT under the 2008 regulations, it is optional for students enrolled under the 2018 regulations.</td>
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**Science in Perspective**

see Science in Perspective: Type A: Enhancement of Reflection Capability

**Recommended Science in Perspective (Type B) for D-ITET**

see Science in Perspective: Language Courses ETH/UZH

**Master’s Thesis**

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>U. Koch</td>
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<tr>
<td></td>
<td>Strongly recommended prerequisite for Semester Projects and Master Theses at D-ITET (MSc BME, MSc EEIT, MSc EST).</td>
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<td></td>
<td>The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.</td>
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<tr>
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<td>Content</td>
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<td>* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, “in this paper” paragraph, scientific part, summary, equations, figures)</td>
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<td>* Topic 2: Structure of Scientific Presentations</td>
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<td>* Topic 3: Citation Rules and Citation Software</td>
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<td>* Topic 4: Guidelines for Scientific Integrity</td>
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<td>ETH &quot;Citation Etiquette&quot;, see <a href="https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html">https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html</a></td>
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<td>ETH &quot;Scientific Integrity&quot;, see <a href="https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html">https://ethz.ch/en/research/ethics-and-animal-welfare/research-integrity.html</a></td>
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<td>Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.</td>
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<th>Supervisors</th>
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<td>b) (if applicable) acquired all credits from additional requirements for admission to msc program</td>
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<td>c) (2018 regulations): acquired the minimum number of credits in the ‘core courses’ category</td>
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<td>-</td>
<td>d) successfully completed the semester project(s)</td>
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</table>
**Current developments and problems of magnetic resonance imaging (MRI)**  
A. Bandeira, F. Dörfler, S. Kozerke, L. Van Gool

**Foundations of Data Science Seminar**  
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

**Research Topics in Biomedical Engineering**  
Does not take place this semester.

**Seminar in Electromagnetics, Photonics and Terahertz**  
Selected topics of the current research activities at the IEF and closely related institutions are discussed.

**Seminar on Biomedical Magnetic Resonance**  
Current developments and problems of magnetic resonance imaging (MRI) and getting insight into advanced topics in magnetic resonance imaging.

**Seminar on Biomedical Engineering**  
Current topics in Biomedical Engineering presented by speakers from academia and industry.

**Research colloquium**  
Selected topics of the current research activities at the IEF and closely related institutions are discussed.

**Generally Accessible Seminars and Colloquia**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>227-0919-00L</td>
<td>Knowledge-Based Image Interpretation</td>
<td>Z</td>
<td>0</td>
<td>2S</td>
<td>L. Van Gool</td>
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<td></td>
<td>Abstact</td>
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<td></td>
<td>With the lecture series on special topics of Knowledge based image interpretation we sporadically offer special talks.</td>
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<tr>
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<td>Objective</td>
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<td>To become acquainted with selected, recent results in image analysis and interpretation.</td>
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<tr>
<td>227-0920-00L</td>
<td>Seminar in Systems and Control</td>
<td>Z</td>
<td>0</td>
<td>1S</td>
<td>F. Dörfler, R. D'Andrea, E. Frazzoli, M. H. Khammash, J. Lygeros, R. Smith</td>
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<td></td>
<td></td>
<td>Current topics in Systems and Control presented mostly by external speakers from academia and industry</td>
</tr>
<tr>
<td>227-0955-00L</td>
<td>Seminar in Electromagnetics, Photonics and Terahertz</td>
<td>Z</td>
<td>3</td>
<td>2S</td>
<td>J. Leuthold</td>
</tr>
<tr>
<td></td>
<td>Abstact</td>
<td></td>
<td></td>
<td></td>
<td>Selected topics of the current research activities at the IEF and closely related institutions are discussed.</td>
</tr>
<tr>
<td>227-0970-00L</td>
<td>Research Topics in Biomedical Engineering</td>
<td>Z</td>
<td>0</td>
<td>1K</td>
<td>K. P. Prüssmann, S. Kozerke, M. Stampanoni, K. Stephan, J. Vörds</td>
</tr>
<tr>
<td></td>
<td>Abstact</td>
<td></td>
<td></td>
<td></td>
<td>Current topics in Biomedical Engineering presented by speakers from academia and industry.</td>
</tr>
<tr>
<td>227-0980-00L</td>
<td>Seminar on Biomedical Magnetic Resonance</td>
<td>Z</td>
<td>0</td>
<td>1S</td>
<td>K. P. Prüssmann, S. Kozerke, M. Weiger Senften</td>
</tr>
<tr>
<td></td>
<td>Abstact</td>
<td></td>
<td></td>
<td></td>
<td>Current developments and problems of magnetic resonance imaging (MRI)</td>
</tr>
<tr>
<td>401-5680-00L</td>
<td>Foundations of Data Science Seminar</td>
<td>Z</td>
<td>0</td>
<td></td>
<td>P. L. Bühlmann, A. Bandeira, H. Bölcskei, S. van de Geer, F. Yang</td>
</tr>
<tr>
<td></td>
<td>Abstact</td>
<td></td>
<td></td>
<td></td>
<td>Research colloquium</td>
</tr>
</tbody>
</table>

**Course Units for Additional Admission Requirements**

*The courses below are only available for MSc students with additional requirements.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-AAL</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>E-</td>
<td>6</td>
<td>8R</td>
<td>H. -A. Loeliger</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a degree declaring this course unit as an additional admission requirement.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>1. Discrete-time linear systems and filters: state-space realizations, z-transform and spectrum, decimation and interpolation, digital filter design, stable realizations and robust inversion.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>2. The discrete Fourier transform and its use for digital filtering.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. The statistical perspective: probability, random variables, discrete-time stochastic processes; detection and estimation: MAP, ML, Bayesian MMSE, LMMSE; Wiener filter, LMS adaptive filter, Viterbi algorithm.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>Lecture Notes.</td>
</tr>
<tr>
<td>227-0103-AAL</td>
<td>Control Systems</td>
<td>E-</td>
<td>6</td>
<td>8R</td>
<td>F. Dörfler</td>
</tr>
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<td></td>
<td>Enrolment ONLY for MSc students with a degree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
</tr>
</tbody>
</table>

Registration in mystudies required!  
Supervisor must be a professor at D-ITET or associated, see https://www.ee.ethz.ch/studies/master-programmes/main-master/projects-and-master-thesis.html
Objective Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.


Prerequisites / notice Prerequisites: Signal and Systems Theory II.

Lecture Slides
High Voltage Engineering

Objective integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Content Review of bipolar and MOS devices and their small-signal equivalent circuit models. Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
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</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
<td></td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<td></td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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</tr>
<tr>
<td></td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negotiation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
<td></td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
<td></td>
</tr>
</tbody>
</table>

### Electrical Engineering and Information Technology Master - Key for Type

| O | Compulsory                                      | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended          | Z  | Courses outside the curriculum       |
| W  | Eligible for credits                          | Dr | Suitable for doctorate               |

### Key for Hours

| V  | lecture                                      | P  | practical/laboratory course         |
| G  | lecture with exercise                       | A  | independent project                 |
| U  | exercise                                    | D  | diploma thesis                      |
| S  | seminar                                     | R  | revision course / private study     |
| K  | colloquium                                  |    |                                       |

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Energy Science and Technology Master

Core Courses
At least two core courses must be passed in each area.
All students must participate in the course offered in the area "Interdisciplinary Energy Management"

Electrical Power Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0122-00L</td>
<td>Introduction to Electric Power Transmission: System &amp; Technology</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>C. Franck, G. Hug</td>
</tr>
</tbody>
</table>

Abstract
Introduction to theory and technology of electric power transmission systems.

Objective
At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of transformers and lines, calculate stationary power flows and other basic parameters in simple power systems.

Content
Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems.

Lecture notes
Lecture script in English, exercises and sample solutions.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>assessed</td>
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</table>

Method-specific Competencies

<table>
<thead>
<tr>
<th>Analytical Competencies</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Decision-making</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td>Not assessed</td>
</tr>
</tbody>
</table>

Social Competencies

<table>
<thead>
<tr>
<th>Communication</th>
<th>Not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Not assessed</td>
</tr>
</tbody>
</table>

Personal Competencies

<table>
<thead>
<tr>
<th>Adaptability and Flexibility</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>Not assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>Not assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>Not assessed</td>
</tr>
</tbody>
</table>

Electric Circuits

<table>
<thead>
<tr>
<th>Students without a background in Electrical Engineering</th>
<th>&quot;Electric Circuits&quot; before taking &quot;Introduction to Electric Power Transmission: System &amp; Technology&quot;</th>
</tr>
</thead>
</table>

Students with no prior knowledge in electrical engineering must take "Electric Circuits" before taking "Introduction to Electric Power Transmission: System & Technology".

Abstract
Introduction to analysis methods and network theorems to describe operation of electric circuits. Theoretical foundations are essential for the analysis of the electric power transmission and distribution grids as well as many modern technological devices – consumer electronics, control systems, computers and communications.

Objective
At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyse simple electric circuits with RLC elements, apply circuit theorems to simple meshed circuits, analyze AC circuits in a steady state and understand the connection of the explained principles to the modelling of the 3-phase electric power systems.

Content
Course will introduce electric circuits variables, circuit elements (resistive, inductive, capacitive), resistive circuits and theorems (Kirchhoffs laws, Norton and Thevenin equivalents), nodal and mesh analysis, superposition principle; it will continue by discussing the complete response circuits (RLC), sinusoidal analysis – ac steady state (complex power, reactive, active power) and conclude with the introduction to 3-phase analysis; Mathematical foundations of the circuit analysis, such as matrix operations and complex numbers will be briefly reviewed. This course is targeting students who have no prior background in electrical engineering.

Lecture notes
Lecture and exercises slides will be distributed after each lecture via moodle platform; additional materials to be accessed online (wileyplus)

Literature
Richard C. Dorf, James A. Svoboda
Introduction to Electric Circuits, 9th Edition
Online materials: https://www.wileyplus.com/
Lecture slides and exercises slides

Prerequisites / notice
This course is intended for students outside of D-ITET. No prior course in electrical engineering is required.

Energy Flows and Processes

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0293-00L</td>
<td>Combustion and Reactive Processes in Energy and Materials Technology</td>
<td>W</td>
<td>4</td>
<td>2V+1U+2A</td>
<td>N. Noiray, F. Ernst, C. E. Frouzakis</td>
</tr>
</tbody>
</table>

Abstract
This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective
The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture “Principles of Microeconomics” is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
The book can also be used for the course ‘Principles of Macroeconomics’ (Sturm)

For students taking only the course ‘Principles of Microeconomics’ there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
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<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
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<td></td>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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</tbody>
</table>

Personal Competencies

<table>
<thead>
<tr>
<th>Adapatability and Flexibility</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>

Interdisciplinary Energy Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Only for Energy Science and Technology MSc.

Abstract
This course will allow the students to get an interdisciplinary overview of the “Energy” topic. It will explore the challenges to build a sustainable energy system for the future. This will be done through the means of case studies that the students have to work on. These case studies will be provided by industry partners.

Objective
The students will understand the different aspects involved in designing solutions for a sustainable future energy system. They will have experience in collaborating in interdisciplinary teams. They will have an understanding on how industry is approaching new solutions.

Lecture notes
Descriptions of case studies.
### Fostered competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

### Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: assessed

### Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Leadership and Responsibility: not assessed
- Negotiation: assessed
- Sensitivity to Diversity: assessed
- Self-presentation and Social Influence: not assessed
- Self-direction and Self-management: assessed

### Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1650-10L</td>
<td>Internship in Industry for Energy Science and Technology MSc.</td>
<td>O</td>
<td>12</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

**Abstract**

The main objective of the 12-week internship is to expose master's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

**Objective**

see above

### Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts (strongly recommended prerequisite)</td>
<td>E</td>
<td>0</td>
<td></td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

**Abstract**

The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

**Objective**

- Knowledge on structure and content of scientific texts and presentations
- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article
- Discussion of the practice of proper citing and scientific integrity

**Content**

- Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, "in this paper" paragraph, scientific part, summary, equations, figures)
- Topic 2: Structure of Scientific Presentations
- Topic 3: Citation Rules and Citation Software
- Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

**Literature**

- ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html

**Prerequisites / notice**

Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1671-10L</td>
<td>Semester Project</td>
<td>O</td>
<td>12</td>
<td>20A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

The semester project is designed to train the students in solving specific problems from the field of Energy Science & Technology. This project uses the technical and social skills acquired during the master's program. The semester project is advised by a professor and must be approved in advance by the tutor.

**Objective**

see above

### Electives

These courses are particularly recommended, other ETH-courses from the field of Energy Science and Technology at large may be chosen in accordance with your tutor.

#### Electrical Power Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0113-00L</td>
<td>Power Electronics</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>J. W. Kolar</td>
</tr>
</tbody>
</table>

**Abstract**

Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

**Objective**

Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; Isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify of weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

High electric fields are used in numerous technological and industrial applications such as electric power transmission and distribution, X-ray devices, DNA sequencers, flue gas cleaning, power electronics, lasers, particle accelerators, copying machines, .... High Voltage Engineering is the art of gaining technological control of high electrical field strengths and high voltages.

Abstract

The students know the fundamental phenomena and principles associated with the occurrence of high electric field strengths. They understand the different mechanisms leading to the failure of insulation systems and are able to apply failure criteria on the dimensioning of high voltage components. They have the ability to identify of weak spots in insulation systems and to propose options for improvement. Further, they know the different insulation systems and their dimensioning in practice.

- discussion of the field equations relevant for high voltage engineering.
- analytical and numerical solutions/solving of this equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components

Content

Lecture Slides

Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice

Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

227-0117-00L

High Voltage Engineering

W

6 credits

4G

C. Franck, U. Straumann

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Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice

Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

227-0247-00L

Power Electronic Systems I

W

6 credits

4G

J. Biela, F. Krismer

Further, they know the different insulation systems and their dimensioning in practice.

- discussion of the field equations relevant for high voltage engineering.
- analytical and numerical solutions/solving of this equations, as well as the derivation of the important equivalent circuits for the description of the fields and losses in insulations
- introduction to kinetic gas theory
- mechanisms of the breakdown in gaseous, liquid and solid insulations, as well as insulation systems
- methods for the mathematical determination of the electric withstand of gaseous, liquid and solid insulations
- application of the expertise on high voltage components
- excursions to manufacturers of high voltage components

Content

Lecture Slides

Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.

Prerequisites / notice

Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

6 credits

6 credits
Abstract
Basics of the switching behavior, gate drive and snubber circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications.

Objective
Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

Content
Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

Lecture notes
Lecture notes and associated exercises including correct answers.

Prerequisites / notice
Prerequisites: Introductory course on power electronics is recommended.

Prerequisites:
A solid base of Analysis I & II as well as of Linear Algebra is really helpful.

Literature
- (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, “Lectures on the Mathematics of Quantum Mechanics I”, 2015, Springer
- (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.

Prerequisites / notice
The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
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<tr>
<td>Method-specific Competencies</td>
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<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

Social Competencies

- Communication

- Cooperation and Teamwork

- Customer Orientation

- Leadership and Responsibility

- Self-presentation and Social Influence

- Sensitivity to Diversity

- Negotiation

Not assessed

Personal Competencies

- Adaptable and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

- Self-awareness and Self-reflection

- Self-direction and Self-management

Assessed

227-0523-00L Railway Systems I

W 6 credits 4G M. Meyer

Abstract

Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

Objective

- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content

EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1 Einführung:
   1.1 Geschichte und Struktur des Bahnystems
   1.2 Fahrdynamik

2 Vollbahnhäufahrzeuge:
   2.3 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
   2.2 Bremsen
   2.3 Traktionsantriebssysteme
   2.4 Hilfsbetriebe und Komfortanlagen
   2.5 Steuerung und Regelung

3 Infrastruktur:
   3.1 Fahrweg
   3.2 Bahnstromversorgung
   3.3 Sicherungsanlagen

4 Betrieb:
   4.1 Interoperabilität, Normen und Zulassung
   4.2 RAMS, LCC
   4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Prerequisites / notice

Dozent:
  Dr. Markus Meyer, Emkamatik GmbH

Lecture notes

Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Geplante Exkursionen:

- Betriebszentrale SBB, Zürich Flughafen
- Reparaturs und Unterhalt, SBB Zürich Altstetten
- Fahrdosentag, Adhesionsfahrt, Flughafen Zürich
- Fahrt mit der SBB, inklusive Fahrzeugfertigung, Stadler, Bussnang

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

227-0526-00L Power System Analysis

W 6 credits 4G G. Hug

Fostered competencies

| Subject-specific Competencies | Concepts and Theories | assessed |
| Method-specific Competencies | Analytical Competencies | assessed |
| Personal Competencies        | Critical Thinking      | assessed |
The goal of this course is understanding the stationary and dynamic problems in electrical power systems and the application of analysis tools in steady and dynamic states.

The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power grids. Approaches such as the Newton-Raphson algorithm applied to power flow equations, superposition technique for short-circuit analysis, equal area criterion and nose curve analysis are discussed as well as power flow computation techniques for distribution grids.

**227-0536-00L Multiphysics Simulations for Power Systems**

**Objective**

The goal of this course is understanding the fundamentals of electromagnetic fields could attend only this course without its 227-0537-00L complement.

**Content**

1. Electromagnetic Fields and Waves: Simulation Aspects (1 lecture, 2 hours)
   a. Short review of the governing equations
   b. Boundary conditions
   c. Initial conditions
   d. Linear and nonlinear material properties
   e. Coupled fields (electro-mechanical and electro-thermal coupling)

2. Finite Element Method for electromagnetic simulations (5 lectures and 3 exercises, 16 hours)
   a. Scalar-FEM in 2-D (electrostatic, magnetostatic, eddy-currents, etc.)
   b. Vector-FEM in 3-D (3-D eddy-currents, wave propagation, etc.)
   c. Numerical aspects of the analysis (convergence, linear solvers, preconditioning, mesh quality, etc.)
   d. Matlab code for 2-D FEM for learning and experimenting

3. Practical applications (5 lectures and 5 exercises, 20 hours)
   a. Dielectric analysis of high-voltage equipment
   b. Nonlinear quasi-electrostatic analysis of surge arresters
   c. Eddy-currents analysis of power transformers
   d. Electromagnetic analysis of electric machines
   e. Very fast transients in gas insulated switchgears (GIS)
   f. Electromagnetic compatibility (EMC)

**227-0731-00L Power Market I - Portfolio and Risk Management**

**Objective**

Knowledge on the worldwide liberalisation of electricity markets, pan-european power trading and the role of power exchanges. Understand financial products (derivatives) based on power. Management of a portfolio containing physical production, contracts and derivatives.

**Content**

1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions

3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hptc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2

2.8. Risk Management 3 (enterprise wide)

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

Lecture notes: Handouts of the lecture
1 excursion per semester, 2 case studies, guest speakers for specific topics.

Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

**Simulation of Photovoltaic Devices - From Materials to W Modules**

**Abstract**
The lecture provides an introduction to the theoretical foundations and numerical approaches for the simulation of photovoltaic power conversion, from the microscopic description of component materials to macroscopic continuum modelling of solar cells and network simulation or effective models for performance prediction of entire solar modules and large scale photovoltaic systems.

**Objective**
Get an overview over the current status of photovoltaic technology. Understand the physics of photovoltaic energy conversion and solar cell device operation. Know how to obtain and assess by simulation the key material properties and device parameters. Be able to use standard device simulation tools to predict the performance of solar cells and modules.

**Content**
Photovoltaic technology: history and overview; The solar spectrum; Thermodynamics of solar energy conversion; Detailed balance models and efficiency limit; Microscopic rates of charge carrier generation and recombination; Optical simulation of solar cells; Models for charge transport in semiconductor devices; High-efficiency wafer-based (silicon) photovoltaics; Thin film photovoltaics based on disordered materials (amorphous silicon, organic PV); High-efficiency thin film photovoltaics (CIGS, CdTe, metal-halide perovskites); PV beyond the single junction detailed balance (Shockley-Queisser) limit; Simulation of photovoltaic modules; Energy yield and performance modelling for PV systems; Quantum simulation of nanostructure-based solar cell devices (bonus lecture)

**Literature**
- M. A. Green, „Solar cells: operating principles, technology, and system applications”, Prentice Hall, 1982.

**Prerequisites / notice**
Undergraduate physics, mathematics, semiconductor devices

**Fostered competencies**
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies

- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation

- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

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**Experimental Methods for Engineers**

**Abstract**
The course presents an overview of measurement tasks in engineering environments. Different concepts for the acquisition and processing of typical measurement quantities are introduced. Following an initial in-class introduction, laboratory exercises from different application areas (especially in thermofluidics, energy, and process engineering) are attended by students in small groups.

**Objective**
Introduction to various aspects of measurement techniques, with particular emphasis on thermo-fluidic, energy, and process-engineering applications. Understanding of various sensing technologies and analysis procedures. Exposure to typical experiments, diagnostics hardware, data acquisition, and processing. Study of applications in the laboratory. Fundamentals of scientific documentation and reporting.

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**Energy Flows and Processes**

**Number**
151-0123-00L

**Title**
Experimental Methods for Engineers

**Type**
W

**ECTS**
4

**Hours**
2V+2U

**Lecturers**

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Data: 01.11.2022 12:41
Autumn Semester 2022
Page 1018 of 2416
### Content
In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy technology, process engineering)

Student participation in 8-10 laboratory experiments (study groups of 3-5 students, dependent on the number of course participants and available experiments)

Lab reports for all attended experiments have to be submitted by the study groups. A final exam evaluates the acquired knowledge individually.

### Lecture notes
Presentations, handouts, and instructions are provided for each experiment.

### Literature


### Prerequisites / notice
Basic understanding in the following areas:
- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

### 151-0163-00L Nuclear Energy Conversion

**Abstract**
Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding.

**Objective**
Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.

**Content**
Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology.

**Lecture notes**
Hand-outs will be distributed. Additional literature and information on the website of the lab:

**Literature**

R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

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### 151-0209-00L Renewable Energy Technologies

**Abstract**
Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

**Objective**
Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

**Lecture notes**
Lecture Notes containing copies of the presented slides.

**Prerequisites / notice**
Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

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### 151-0216-00L Wind Energy

**Abstract**
The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. These subjects are introduced through a discussion of the basic principles of wind energy generation and conversion, and a detailed description of the broad range of relevant technical, economic and environmental topics.

**Objective**
The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy.

**Content**
This mechanical engineering course focuses on the technical aspects of wind turbines; non-technical issues are not within the scope of this technically oriented course. On completion of this course, the student shall be able to conduct the preliminary aerodynamic and structural design of the wind turbine blades. The student shall also be more aware of the broad context of drivetrains, dynamics and control, electrical systems, and meteorology, relevant to all types of wind turbines.

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### 151-0221-00L Introduction to Modeling and Optimization of Sustainable Energy Systems

**Abstract**
This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

**Objective**
At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course "Introduction to Modeling and Optimization of Sustainable Energy Systems", the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

**Content**
The global energy transition; Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

**Lecture notes**
Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

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### 151-0251-00L Principles, Efficiency Optimization and Future Applications of IC Engines

**Abstract**

**Objective**
The students get familiar with operating characteristics and efficiency maximization methods of IC engines for propulsion and decentralized electricity (and heat) generation. To this end, they learn about simulation methods and related experimental techniques for performance assessment in a combination of lectures and exercises.
Content
This lecture aims at introducing the students to the working principles and efficiency optimization methods for Internal Combustion (IC) engines which are expected to continue to play a very important role in transportation (long-haul heavy duty, marine) and decentralized combined heat and power generation. Following an overview of different applications and powertrains, the course will focus on the following topics: First, a generic overview of the history of IC-Engines is given, and the basic dimensions and specific engine-relevant terminology are introduced. Next, operating maps for different duty cycles are discussed, highlighting the benefits of individual powertrain configurations for different usage scenarios. The high-pressure thermodynamic process and combustion-induced heat release are analyzed in detail and the design of the combustion processes is discussed in view of further optimization of the energy conversion efficiency. The concept of boosting, its challenges and potential are also presented. In addition, flow field characteristics, convective and radiative heat transfer and combustion modes (Otto, Diesel and "multi-mode" cycles) will be discussed along with possible simulation methods. The course consists of lectures combined with exercises. In addition, several invited guest talks will be held by representatives from Swiss industrial companies active in this field. Provided the pandemic measures allow, visits to different engine test facilities are further envisioned.

Literature

Prerequisites / notice
This course provides background for the course 151-0254-00L "Environmental Aspects of Future Mobility" held in the Spring Semester, where the focus is on emission formation and minimization, exhaust gas after treatment systems and potentials of future synthetic/e-fuels in IC engines; all given in the broader context of a future mobility/transportation options (battery electric, hybrids, fuel cells etc.) and transformation pathways towards sustainability.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies

151-0293-00L
Combustion and Reactive Processes in Energy and Materials Technology
4 credits
W 2V+1U+2A
20 credits
N. Noiray, F. Ernst, C. E. Frouzakis

Abstract
This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective
The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content

Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Literature


151-0567-00L
Engine Systems
4 credits
W 3G

Abstract
Introduction to current and future engine systems and their control systems

Objective
Introduction to methods of control and optimization of dynamic systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantifiable descriptions.

Content
Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.). Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions.

Lecture notes
Introduction to Modeling and Control of Internal Combustion Engine Systems
Guzzella Lino, Onder Christopher H.
ISBN: 978-3-642-10774-0

Prerequisites / notice
Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups

151-0569-00L
Vehicle Propulsion Systems
4 credits
W 3G

Abstract
Introduction to current and future propulsion systems and the electronic control of their longitudinal behavior

Objective
Introduction to methods of system optimization and controller design for vehicles. Understanding the structure and working principles of conventional and new propulsion systems. Quantitative descriptions of propulsion systems

Content
Understanding of physical phenomena and mathematical models of components and subsystems (manual, automatic and continuously transmissions, energy storage systems, electric drive trains, batteries, hybrid systems, fuel cells, road/wheel interaction, automatic braking systems, etc.). Presentation of mathematical methods, CAE tools and case studies for the model-based design and control of propulsion systems with the goal of minimizing fuel consumption and emissions.

Lecture notes
Vehicle Propulsion Systems: Introduction to Modeling and Optimization
Guzzella Lino, Sgarretta Antonio
ISBN: 978-3-642-35912-5

Prerequisites / notice
Lectures of Prof. Dr. Ch. Onder and Dr. Ph. Elbert are also possible to be held in German.

529-0613-01L
Process Simulation and Flowsheeting
6 credits
W 3G

Abstract
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheeting and optimization problems.
Objective
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Content
Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

Literature
An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice
A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

Energy Economics and Policy

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0577-00L</td>
<td>An Introduction to Sustainable Development in the Built Environment</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Habert, D. Kaushal</td>
</tr>
</tbody>
</table>

Abstract
In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict. What does it mean for the built environment? This course provides an introduction to the notion of sustainable development when applied to our built environment.
Objective
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

Content
The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

Lecture notes
All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

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102-0317-00L

**Advanced Environmental Assessments**

Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0317-00 Advanced Environmental Assessments (3KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

**Abstract**
This course deepens students' knowledge of the environmental assessment methodologies and their various applications.

**Objective**
This course has the aim of deepening students' knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors.

- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers

**Content**
- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

**Lecture notes**
No script. Lecture slides and literature will be made available on Moodle.

**Literature**
Literature will be made available on Moodle.

**Prerequisites / notice**
Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods and Technologies</th>
<th>Analytical Competencies</th>
<th>Media and Digital Technologies</th>
<th>Problem-solving</th>
<th>Critical Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td>assessed</td>
<td>not assessed</td>
<td>assessed</td>
</tr>
</tbody>
</table>

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102-0317-03L

**Advanced Environmental Assessment (Computer Lab)**

**Abstract**
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice.

**Objective**
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.
Not for master students in Environmental Engineering choosing module Ecological Systems Design as already included in Environment and Computer Laboratory I (Year Course): 102-0527-00 and 102-0528-00.

Abstract
Technical systems are investigated in projects, based on the software and tools introduced in the course 102-0317-03L Advanced Env. Assessment (Computer Lab I). The projects are created around a complete but simplified LCA study, where the students will learn how to answer a given question with target oriented methodologies using various software programs and data sources for env. assessment.

Objective
Become acquainted with utilizing various software programs for environmental assessment to perform a Life Cycle Assessment and learn how to address the challenges when analyzing a complex system with available data and software limitations.

Prerequisites / notice
Prerequisite is enrolment of 102-0317-00 Advanced Environmental Assessments and of 102-0317-03 Advanced Environmental Assessments (Computer Lab I) in parallel or in advance (both courses in HS).

Fostered competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management not assessed

Personal Competencies
- Critical Thinking assessed
- Communication assessed
- Cooperation and Teamwork not assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed

102-0327-01L Implementation of Environmental and Other Sustainability Goals
Master student in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0327-01 Advanced Environmental Assessments (2KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

Abstract
This course teaches approaches and methods to identify, assess and manage environmental and societal aspects in organisations, such as ISO 14001 or the ecobalance of organisations, and how such approaches fit into a management system.

Objective
Students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including ‘organisational LCA’ (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- apply life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of ‘Continuous Improvement’
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including ‘organisational LCA’ (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Content
Students will get small exercises related to course issues.

Lecture notes
Documents will be available on Ilias

Literature
Will be made available.

Prerequisites / notice
This course is meant for any interested student, except students of Ecological Systems Design (who should not choose this stand-alone course, but the combined course, specifically offered and mandatory for their module).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic will profit more from this course after reading an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).
Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overdose of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share his insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

Lecture notes
http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Presentation slides will be made available on moodle prior to lectures.

Prerequisites / notice
TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

<! Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET

see Science in Perspective: Language Courses ETH/UZH

<! Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1101-00L</td>
<td>How to Write Scientific Texts</td>
<td>Strongly recommended prerequisite for Semester Projects and Master Theses at D-ITET (MSc BME, MSc EEIT, MSc EST).</td>
<td>E-</td>
<td>0 credits</td>
<td>U. Koch</td>
</tr>
</tbody>
</table>

The four hour lecture covers the basics of writing and presenting of scientific work. The focus is on the structure and the main elements of a scientific text rather than the language. Citation rules, good practice of scientific writing and an overview on software tools are part of the training.

Knowledge on structure and content of scientific texts and presentations

- Stimulation of a discussion on how to write a scientific text versus an interesting novel or news article

- Discussion of the practice of proper citing and scientific integrity
Content

* Topic 1: Structure of Scientific Texts (title, author list, abstract, state-of-the-art, "in this paper" paragraph, scientific part, summary, equations, figures)
* Topic 2: Structure of Scientific Presentations
* Topic 3: Citation Rules and Citation Software
* Topic 4: Guidelines for Scientific Integrity

The lecture will be given in two parts on two afternoons. Some exercises will be built into the lecture.

Literature

ETH "Citation Etiquette", see https://ethz.ch/students/en/studies/performance-assessments/plagiarism.html

Prerequisites / notice

Students should be writing either a bachelor/semester/master thesis or a scientific publication in the immediate future.

<table>
<thead>
<tr>
<th>227-1601-00L</th>
<th>Master's Thesis</th>
<th>O</th>
<th>30 credits</th>
<th>40D</th>
<th>Supervisors</th>
</tr>
</thead>
</table>

Only students who fulfill the following criteria are allowed to enroll for and start with their master thesis:

a. successful completion of the bachelor program;
b. any additional requirements necessary to gain admission to the master program EST have been successfully completed;
c. both the semester project and the internship have been successfully completed.

Registration in mystudies required!

Abstract

The master program in Energy Science and Technology culminates in a six months research project which addresses a scientific research questions on one's chosen area of specialization. The masters thesis is supervised by a program-affiliated faculty member and the topic must be approved in advance by the tutor.

Objective

see above

Energy Science and Technology Master - Key for Type

<table>
<thead>
<tr>
<th>W</th>
<th>Eligible for credits</th>
<th>Dr</th>
<th>Suitable for doctorate</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Chemistry I

**Number** 529-2001-02L  
**Title** Chemistry I  
**Type** O  
**ECTS** 4 credits  
**Hours** 2V+2U  
**Lecturers** J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel

**Abstract**  
In the course “Chemistry I”, the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

**Objective**  
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

**Content**  
1. Stoichiometry  
   Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.  
2. Atoms  
   Elementary particles and atoms. Electron configuration of the elements. Periodic system.  
4. Basics of chemical thermodynamics  
   System and surroundings. Description of state and change of state of chemical systems.  
5. First law of thermodynamics  
6. Second law of thermodynamics  
   Entropy. Change of entropy in chemical systems and universe. Reaction entropy.  
8. Chemical equilibrium  
   Law of mass action. Reaction quotient and equilibrium constant. Phase transition equilibrium.  
9. Acids and bases  
10. Dissolution and precipitation.  
    Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

**Lecture notes**  
Online-Skript mit durchgerechneten Beispielen.

**Literature**  

Weiterführende Literatur:  


### Mathematics I

**Number** 401-0251-00L  
**Title** Mathematics I  
**Type** O  
**ECTS** 6 credits  
**Hours** 4V+2U  
**Lecturers** A. Cannas da Silva

**Abstract**  
This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

**Objective**  
Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.
First Year Additional Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0030-00L</td>
<td>Laboratory Course: Elementary Chemical Techniques</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>A. de Mello, F. Jenny, M. H. Schroth</td>
</tr>
</tbody>
</table>

Basic Courses II

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0000-03L</td>
<td>Laboratory Course in Physics for Students in Earth Sciences</td>
<td>O</td>
<td>2</td>
<td>4P</td>
<td>A. Biland, A. Eggenberger, A. Müller</td>
</tr>
</tbody>
</table>
Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.

Lecture notes
A script will be distributed

Literature
Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Wiley-VCH, 2012
ISBN 3527411445, 9783527411443

Douglas C. Giancoli
Physik
3. erweiterte Auflage
Pearson Studium

Hans J. Paus
Physik in Experimenten und Beispielen
Carl Hanser Verlag, München, 2002, 1088 S.

Paul A. Tipler
Physik
Spektrum Akademischer Verlag, 1998, 1522 S., ca Fr. 120.-

David Halliday Robert Resnick Jearl Walker
Physik
Wiley-VCH, 2003, 1388 S., Fr. 87.- (bis 31.12.03)

dazu gratis Online Ressourcen (z.B. Simulationen): www.halliday.de

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies not assessed
Decision-making not assessed
Problem-solving assessed

Social Competencies
Communication not assessed

651-3400-00L Geochemistry I O 4 credits 3G M. Schönächler, D. Vance

Abstract
Introduction to geochemistry and its application to the study of the origin and evolution of the Earth and planets.

Objective
Gain an overview of geochemical methods used in various fields of Earth Sciences and how they can be applied to study geological processes in the Earths mantle, crust, oceans and atmosphere.

Content
This course is an introduction into geochemistry with a special focus on the basic concepts used in this rapidly evolving field. The course deals with the geochemist's toolbox: the basic chemical and nuclear properties of elements from the periodic table and how these elements can be used to ask fundamental questions in Earth Sciences. The important concepts used in solid-solution-gas equilibria are introduced. The concepts of chemical reservoirs and geochemical cycles are discussed with examples from the carbon cycle in the Earth. The course also addresses geological applications in low- and high-temperature geochemistry, including the formation of continents, the differentiation of the Earth, the geochemistry of ocean and continental waters.

Lecture notes
The slides are available online.

Literature

Prerequisites / notice
Prerequisite: chemical thermodynamics, basic inorganic chemistry and physics.

701-0023-00L Atmosphere O 3 credits 2V E. Fischer, T. Peter

Abstract
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Objective
Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - oceans - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Content
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Lecture notes
Written information will be supplied.

Literature
This course is designed to provide an introduction to hydrogeology and oceanography for all Earth Science students at ETH. It provides an overview of the physical controls on water flow in streams, aquifers, and the oceans. It also deals with the basics of groundwater chemistry, biogeochemical cycling in the oceans, the role of the oceans as carbon reservoirs and their dynamic redox state.

To understand and describe the basic principles of the hydrologic cycle and water flow in streams and aquifers.

To discuss the cycles of carbon and oxygen in the ocean, with a view to the critical analysis of how the oceans respond to, cause and record the dynamics of these cycles in Earth history.

To describe how these controls interact to drive surface and interior ocean circulation.

Objective

Content

The hydrogeology component will: 1) describe the hydrologic cycle, with a focus on the importance of groundwater to society; introduce the basics of groundwater chemistry, including major ions and mean meteoric water line, basics of groundwater contamination; 2) introduce the interface with the oceans, including hydrothermal circulation at mid-ocean ridges, ocean-water intrusion into groundwater at coasts.

The oceanography component will: 1) provide an overview of the physical circulation of the oceans, including its importance for heat transfer around the surface of the Earth and for climate; 2) describe the basic processes that control the chemistry of the oceans, including its temporal and spatial variability; 3) introduce some simple concepts in biological oceanography, including the dependence of ocean ecology on nutrient distributions. There will be a specific focus on how the physics, chemistry and biology of the ocean might have changed through Earth history, and the impact of oceanic processes on Earth's climate.

Lecture notes

Available

Literature


Prerequisites / notice

Chemie I and II, Physik I and II, Mathematik I and II.

General Earth Sciences Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4143-00L</td>
<td>Geobiology</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>T. I. Eglinton, C. Magnabosco, C. Welte, S. Wohlwend</td>
</tr>
</tbody>
</table>

We will study traces in the lithosphere that have been left behind by organisms during the course of Earth history and mineral components, which were built through biological processes or used as sources of energy and nutrients by organisms. Traces of life from the past will be compared with the development of the diversity of today's organisms.

The course will allow you to ask questions about the origin and the evolution of life on Earth, to understand contemporary hypotheses and create new methods of developing them further. Theory is supplemented with observations in the field, exercises and the application of simple mathematical models. The course will enable you to integrate geobiological knowledge into topics that will be taught in subsequent earth science courses and into the current understanding of Earth history. You will learn to better understand modern geological settings and, if necessary, to recommend biogeochemically well-founded and responsible interventions or protective measures.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1029 of 2416
The course focuses on (a) geobiochemical cycles that play major roles in Earth history in aquatic and terrestrial ecosystems, (b) biosynthetic and metabolic processes, which are essential for life, (c) organisms which regulate and maintain geochemical cycling, and (d) chemical signals of past life in the geological record. Accordingly, we must understand
  -- how biological cells and its components are built from essential elements and molecules,
  -- how cells function and which life styles organisms developed,
  -- where organisms can exist and which factors select for their presence,
  -- where biologically usable forms of energy come from, and under which conditions they can be exploited,
  -- how biological metabolism can change environmental conditions and composition,
  -- which biological products can lead to signals preserved in the rock record, and how biomolecules and elements are altered in sedimentary deposits,
  -- how organic and inorganic components are cycled through the biosphere, and how biogeochemical cycles function,
  -- how "biological innovations" evolved and changed in response to environmental changes.

Applied Case Studies, which supplement and illustrate the contents:
-- Scientific applications of geobiological knowledge are found in fields like Microbial Ecology, Geochemistry, Palaeontology, Sedimentology, Petrology, Ocean Research, Environmental Sciences, Astrobiology and Archaeology.
-- Practical applications of geobiological knowledge are needed in fields like stabilisation of existing and design of safe waste repositories, surveilling ground water resources, sewage treatment, exploitation of and prospecting for fossil carbon sources, soil remediation, mineral exploration and teaching, forensic science and medicine.

Prerequisites / notice
As integraler Bestandteil der Vorlesung wird eine Exkursion durchgeführt.

651-3301-00L Crystals and Minerals

Objective
At the end of this course students should be able to:
  • Define the fundamental concepts of crystals such as lattice, motif, unit cell, crystal systems, lattice systems, symmetry, point groups, space groups, Miller indices, close-packed structures, and so on.
  • Classify the crystal structures in a proper way.
  • Describe the crystal structures in a proper way.
  • Be familiar with the important crystal structures related to the Earth Sciences.
  • Be familiar with the measurement techniques to characterize the crystal structures and chemistry.

At the end of the Mineralien hands-on course, the students will be able to determine and describe the macroscopically observable properties of about 70 minerals and know the sum formulae of about 50 of them.

Content
Crystallography course:
  • Minerals & Crystals
  • Lattice
  • Motif (or Basis)
  • Unit cell
  • Crystal coordinate system
  • Lattice parameters
  • The 7 crystal systems
  • The 14 Bravais lattices
  • Symmetry
  • Point groups
  • Space groups
  • Miller Indices
  • d-spacing
  • Crystal densities
  • Close-packed structure
  • HCP & CCP structures
  • Metallic crystals
  • Ionic crystals
  • Covalent crystals
  • Phase transitions
  • Bragg's Law
  • X-ray diffraction
  • Spectroscopic methods

Minerals hands-on course:
About 70 of the most important rock-forming and ore minerals and their properties

Lecture notes
Tabellen zum Mineralbestimmen, W.F. Oberholzer und V.Dietrich

Literature
1. Solid State Chemistry and Its Applications, Anthony R. West
2. Solid State Physics, Gerald Burns

Mineralien hands-on course:
Tabellen zum Mineralbestimmen, W.F. Oberholzer und V.Dietrich

651-4271-00L Data Analysis and Visualisation with Python in Earth Sciences

Abstract
This lecture and the corresponding exercises provide the students with an introduction to the concepts and tools of programming and scientific data analysis. Using examples from Earth Sciences, the students solve problems of increasing complexity using the programming language Python. Students also learn how to effectively visualise different kinds of datasets.

Objective
The following concepts are introduced in the course:
- Fundamentals of programming
- Analysis of datasets of different types
- Effective and scientifically correct visualisation
- Statistical description of a dataset

651-3402-00L Magmatism and Metamorphose I

Content
About 70 of the most important rock-forming and ore minerals and their properties

Lecture notes
Tabellen zum Mineralbestimmen, W.F. Oberholzer und V.Dietrich

Literature
1. Solid State Chemistry and Its Applications, Anthony R. West
2. Solid State Physics, Gerald Burns

Mineralien hands-on course:
Tabellen zum Mineralbestimmen, W.F. Oberholzer und V.Dietrich
This course treats the generation and evolution of igneous rocks as well as the metamorphism of igneous and sedimentary rocks as products of geodynamic processes operating within the Earth’s interior. The course combines petrography, geochemistry, experimental and theoretical petrology to assess fundamental igneous and metamorphic processes controlling the generation and evolution of igneous and metamorphic rocks in time and space. Principle targets are (1) the generation of magmas in the Earth mantle and crust, differentiation and emplacement of magmas at depth and on the surface and (2) metamorphism of igneous and sedimentary rock series and their relationships in the framework of global tectonics. The material is mostly presented in qualitative way. A quantification of igneous and metamorphic processes based on modal mineralogy, geochemistry, phase petrology and thermodynamic principles is assessed and further promoted in the accompanying homework and exercises.

Basic knowledge of rock-forming minerals and the classification of igneous and metamorphic rocks are required and will be further trained during the exercises.

**Integrated Earth Systems**

**Number** 651-4180-02L

**Abstract**
The surface Earth is often thought of as a set of interacting systems, often with feedbacks between them. These interacting systems control the tectonics, geomorphology, climate, and biology of the surface Earth. To fully understand the nature of the Earth System, including the controls on its past evolution, its present state, and its future, an integrated perspective is required.

**Objective**
To introduce students to an integrated view of the surface Earth, uniting perspectives from different disciplines of the earth sciences.

**Content**
- Planet Earth has had a complex history since its formation ~4.6 billion years ago. The surface Earth is often thought of as a set of interacting systems, often with positive and negative feedbacks between them. These interacting systems control the tectonics, geomorphology, climate, and biology of the surface Earth. To fully understand the nature of the Earth System, including the controls on its past evolution, its present state, and its future, an integrated perspective is required. This is a subject that pulls in observations and models from many areas of the Earth Sciences, including geochemistry, geophysics, geology and biology. The main goal of the course is to convey this integrated view of the surface of our planet.

We will achieve this integrated view through a series of lectures, exercises, and tutorials. We take as our framework some of the key events in Earth history, encouraging understanding of the controlling processes through integrated observations, ideas and models from disciplines across science.

**Majors**

**Major: Geology and Geophysics**

Advisors of the major in Geology and Geophysics are Dr. Vincenzo Picotti (Geology) and Dr. Jérôme Noir (Geophysics).

**Methods**

**Number** 651-3527-00L

**Abstract**
Reading and interpretation of geological maps.

**Objective**
All participants are able to:
- Read and understand complex geological maps;
- Assess, select, and project information from real case studies;
- Make tectonic overview sketches and construct meaningful cross-sections;

**Content**
Advanced analysis of geological maps and construction of geological sections. Special points: normal faults of the Rheintal graben, Val de Ruz, Helvetic nappes of the Säntis area. Reconstruction of the geological history of the map areas. References to the Geology of Switzerland.

**Lecture notes**
Exercises and instructions are handed out.

**Literature**
Not required but for reference (in library holdings):

**Prerequisites / notice**
Requirement: Earth science mapping exercises I

**Number** 401-0624-00L

**Abstract**
Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

**Objective**
Capacity to learn from data: good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.
The course focuses on the most important systems of radioactive and stable isotopes used in geochemistry and geology. Applications of...
This introductory course starts from a description of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.


Overview and understanding of the most important geophysical methods: Potential field methods (Gravimetrics and Magnetics), Electrical and electromagnetic methods, Refraction and reflection seismics, Georadar. Discussion of survey design, sources and receivers and data processing. Programmes and interpretation procedures. Examples of specific problems, like landfills and rockslides. There will also be demonstrations in the classroom.

Process understanding, modeling, data analysis & interpretation and measurement procedures. Examples of specific problems, like landfills and rockslides. There will also be demonstrations in the classroom.

In the course "Cryosphere", the competencies of process understanding, modeling, data analysis & interpretation and measurement procedures. Examples of specific problems, like landfills and rockslides. There will also be demonstrations in the classroom.
Content

The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.

Lecture notes

Handouts will be distributed during the teaching semester

Literature


Further literature will be indicated during the lecture.

Fostered competencies

Subject-specific Competencies

Concepts and Theories
assessed
Techniques and Technologies
assessed

Method-specific Competencies

Analytical Competencies
assessed
Decision-making
not assessed
Media and Digital Technologies
assessed
Problem-solving
assessed
Project Management
not assessed

Social Competencies

Communication
not assessed
Cooperation and Teamwork
not assessed
Customer Orientation
not assessed
Leadership and Responsibility
not assessed
Self-presentation and Social Influence
not assessed
Sensitivity to Diversity
not assessed
Negotiation
not assessed

Personal Competencies

Adaptability and Flexibility
assessed
Creative Thinking
assessed
Critical Thinking
assessed
Integrity and Work Ethics
not assessed
Self-awareness and Self-reflection
not assessed
Self-direction and Self-management
not assessed

ECTS

Title

Principles of Natural Hazard Management
W
3 credits
4G
V. Griess, A. Mathys

Abstract

This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.

Objective

By the end of the course, students will be able to:

- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.
- develop, formulate and present solutions to these challenges to a critical audience.

Choice of courses from the complete offerings of ETH.

Bachelor's Seminar

The Bachelor's Seminar is only offered in the spring semester.

Number

Title

Type

ECTS

Hours

Lecturers

651-3597-00L
Bachelor's Seminar I
O
2 credits
2S
W. Schatz, J. D. Rickli

Abstract

In this seminar, students learn to search efficiently for scientific literature and to present scientific findings orally and in written form.

Objective

The students learn the principles of presenting scientific material orally. They become acquainted with the structure of scientific publications, and learn how to find, read and evaluate scientific literature. Furthermore, the course will introduce basic aspects of scientific writing.

Major: Climate and Water

Advisor of the BSc-major "Climate and Water" is Dr. Hanna Joos, Institute for climate and atmosphere (IAC).

Advanced

Number

Title

Type

ECTS

Hours

Lecturers

701-0471-01L
Atmospheric Chemistry
W
3 credits
2G
M. Ammann, T. Peter

Abstract

This self-study course provides an introduction to atmospheric chemistry at bachelor level. It introduces the fundamentals of gas phase reactions, the concept of solubility and reactions in aerosols and in clouds. It explains the chemical and physical processes responsible for global (e.g. stratospheric ozone depletion) as well as regional environmental problems (e.g. urban air pollution).

Objective

The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere.

The students will also acquire a good understanding of atmospheric environmental problems including air pollution, tropospheric ozone formation, stratospheric ozone destruction and the relationship between air pollution and climate change.

Content

- Origin and properties of the atmosphere: structure, large scale dynamics, UV radiation
- Thermodynamics and kinetics of gas phase reactions: enthalpy and free energy of reactions, rate laws, mechanisms of bimolecular and termolecular reactions.
- Tropospheric photochemistry: Photolysis reactions, photochemical O3 formation, role and budget of HOx, dry and wet deposition
- Aerosols and clouds: chemical properties, primary and secondary aerosol sources, phase transfer kinetics, solubility and hygroscopicity, N2O5 chemistry, SO2 oxidation, secondary organic aerosols
- Air quality: role of planetary boundary layer, summer- versus winter-smog, environmental problems, legislation, long-term trends
- Stratospheric chemistry: Chapman cycle, Brewer-Dobson circulation, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol
- Global aspects: global budgets of ozone, methane, CO and NOx, air quality - climate interactions

Lecture notes

Lecture materials (slides and annotations) of the most recent corresponding bachelor course are provided.

Prerequisites / notice

Basic courses in chemistry and physics are expected.
Atmospheric Physics

Abstract
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.

Objective
Students are able
- to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

Content
The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to classify radiosondes with the help the thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed. With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

Lecture notes
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15367

Literature

Prerequisites / notice
For certain capters we’ll use the concept of “flipped classroom” (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Communication assessed
Personal Competencies
Critical Thinking assessed
Self-direction and Self-management assessed

Cryosphere

Abstract
The course introduces the different components of the cryosphere - snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.

Objective
Students are able to
- qualitatively explain relevant processes, feedbacks and relationships between the different components of the cryosphere,
- quantify and interpret physical processes, which determine the state of the cryospheric components, with simple calculations.

In the course “Cryosphere”, the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

Content
The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.

Lecture notes
Handouts will be distributed during the teaching semester

Literature

Further literature will be indicated during the lecture.
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical aspects of regression analysis are covered, and practical exercises will strengthen the learning process. A script will be available.

This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes

Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not necessary, a Python introduction is provided). Example programs and graphics tools are supplied.

The students are able to:
- develop simple numerical schemes and to implement these schemes using the programming language Python.
- critically assess such models and their results.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and Poisson regression for count data.

The students are able to:
- work with different types of data and to choose appropriate statistical models.
- critically assess such models and their results.

The students are able to:
- develop simple numerical schemes and to implement these schemes using the computer language Python.
- critically assess such models and their results.


<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0461-00L</td>
<td>Numerical Methods in Environmental Physics</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Schär, C. Zeman</td>
</tr>
<tr>
<td>701-0473-00L</td>
<td>Weather Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. A. Sprenger, F. Scholder-Aemisegger</td>
</tr>
</tbody>
</table>

### Electives

The electives are recommended. Additional courses can be chosen from the complete offerings of the ETH Zurich and University of Zurich.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Detting</td>
</tr>
<tr>
<td>401-0650-00L</td>
<td>Numerical Methods in Environmental Physics</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Schär, C. Zeman</td>
</tr>
<tr>
<td>701-0473-00L</td>
<td>Weather Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. A. Sprenger, F. Scholder-Aemisegger</td>
</tr>
</tbody>
</table>

### Literature

- Faraway (2005): Linear Models with R
- Faraway (2006): Extending the Linear Model with R
- Draper & Smith (1998): Applied Regression Analysis
- Fox (2008): Applied Regression Analysis and GLMs
- Montgomery et al. (2006): Introduction to Linear Regression Analysis
The course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.
Students are able
- to name the bases, concepts and methods of environmental fluid dynamics.
- to understand and discuss the components of the basic physical equations in fluid dynamics
- to apply basic mathematical equations to simple problems of environmental fluid dynamics.

The competencies of process understanding and system understanding are taught, applied and examined.

Basic physical terminology and mathematical laws:
- Continuum hypothesis, forces, constitutive laws, state equations and basic principles of thermodynamics, kinematics, laws of mass and momentum on rotating earth.
- Concepts and illustrative flow systems: vorticity dynamics, boundary layers, instability, turbulence - with respect to environmental fluid systems.
- Scale analysis: dimensionless variables and dynamical similarity, simplification of the fluid system, e.g. shallow water assumption, geostrophic flow.

Waves in environmental fluid systems.

The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge variety of statistical and graphical methods. It is used in many fields of science. R is an implementation of the language and environment for statistical computing and graphics. The students will be able to use the software R for simple data analysis and graphics.

Lecture notes

Subject-specific Competencies
- Concepts and Theories
  - assessed
  - Techniques and Technologies
    - not assessed

Method-specific Competencies
- Analytical Competencies
  - assessed
  - Decision-making
    - not assessed
  - Media and Digital Technologies
    - not assessed
  - Problem-solving
    - assessed
  - Project Management
    - not assessed

Social Competencies
- Communication
  - not assessed
  - Cooperation and Teamwork
    - not assessed
  - Customer Orientation
    - not assessed
  - Leadership and Responsibility
    - not assessed
  - Self-presentation and Social Influence
    - not assessed
  - Sensitivity to Diversity
    - not assessed
  - Negotiation
    - not assessed

Personal Competencies
- Adaptability and Flexibility
  - not assessed
  - Creative Thinking
    - assessed
  - Critical Thinking
    - assessed
  - Integrity and Work Ethics
    - not assessed
  - Self-awareness and Self-reflection
    - not assessed
  - Self-direction and Self-management
    - not assessed

401-0624-00L Mathematics IV: Statistics

Objective
- Capacity to learn from data: good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.

Content
  - einschliesslich Binomialtest, t-Test, Vorzeichentest, F-Test, Wilcoxon-Test), Vertrauensintervalle, Vorhersageintervalle, Korrelation, einfache und multiple lineare Regression. Einführung in die statistische Programmiersprache R.

Lecture notes
- Ausführliches Skript zur Vorlesung ist erhältlich.

Literature

Prerequisites
- Die Übungen (ca. die Hälfte der Kontaktstunden; einschliesslich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

401-6215-00L Using R for Data Analysis and Graphics (Part I)

Objective
- The students will be able to use the software R for simple data analysis and graphics.
- The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Content
- Part I of the course covers the following topics:
  - What is R?
  - R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
  - Types of data: numeric, character, logical and categorical data, missing values;
  - Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
  - Writing simple functions;
  - Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

Lecture notes
- An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf
- The course resources will be provided via the Moodle web learning platform.

Prerequisites
- An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf
- The course resources will be provided via the Moodle web learning platform.

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed
Cooperation and Teamwork not assessed
Creative Thinking assessed

Choice of courses from the complete offerings of ETH.

►►► Laboratory Course
The practical takes place in spring semester.

►►► Bachelor’s Seminar

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0459-00L</td>
<td>Seminar for Bachelor Students: Atmosphere and Climate</td>
<td>O</td>
<td>3 credits</td>
<td>2S</td>
<td>R. Knutti, C. Brunner, O. Stebler</td>
</tr>
</tbody>
</table>

Abstract
In this seminar all students in the realm of atmospheric and climate science from D-ERDW and D-USYS convene to train presentation techniques (talks, posters) by means of classic and modern scientific articles.

Objective
In this seminar, students learn how to read scientific publications and how to transfer the scientific knowledge to a broader audience by means of oral and poster presentations. Students also get insight into the different research areas at the Institute for Atmospheric and Climate Science.

Content
1st week: course organisation and presentation of the institute
2nd and 3rd week: introduction to oral presentation technique
week 4 to 10: students talks
11th week: introduction to poster presentation technique
12th and 13th week: poster design
14th week: concluding poster presentation

Lecture notes
Documents are offered via the course's web page.

Literature
Documents are offered via the course's web page.

Prerequisites / notice
This course can only be offered to a limited number of students, however, in any case for everybody having to attend it compulsory. We beg you to sign in to this course early.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Social Competencies
- Cooperation and Teamwork
- Communication

Personal Competencies
- Creative Thinking
- Critical Thinking

► Science in Perspective

►► Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ERDW

►► Language Courses

see Science in Perspective: Language Courses ETH/UZH

► Bachelor’s Thesis

The Bachelor Thesis and Bachelor-Seminar are offered once per year in the 6th semester, in the spring semester.

Earth and Climate Sciences Bachelor - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
<th>Z</th>
<th>Courses outside the curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>O</td>
<td>Compulsory</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1039 of 2416
### Earth Sciences Master

- **Major in Geology**

#### Compulsory Module in Analytical Methods in Earth Sciences

Students have to complete 6 credits in part A, and 6 credits in part B.

#### Part A: Microscopy Courses

<table>
<thead>
<tr>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4045-00L</td>
<td>Microscopy of Metamorphic Rocks</td>
<td>W+</td>
<td>2</td>
<td>2G</td>
<td>A. Galli</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>- Advanced knowledge in optical mineralogy. - Application of methods to determine minerals in thin sections. - Identification and characterisation of metamorphic minerals. - Description of rocks. Derive correct petrographic rock name, based on modal abundance and microstructure/texture. - Interpretation of rock fabric/microstructure, parageneses and mineral reactions.</td>
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<tr>
<td><strong>Content</strong></td>
<td>- Repetition of principal optical properties and of microscopic methods to identify minerals. Emphasis on interpretation of interference figures. - Study typical metamorphic rocks in thin sections. - Description and interpretation of parageneses and texture/microstructures. Study the age relationship of crystallisation and deformation. - Estimation of metamorphic grade. - Quantification. To determine volume percentage of rock components. - Scientific documentation: Descriptions, drawings, photomicrography using different kinds of illumination and using plane- or circular-polarised light.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Number of participants: 24. Participants should have basic knowledge in crystallography, mineralogy and petrology, and have taken practical courses in microscopy of thin sections, as well as lectures in metamorphic petrology and structural geology! Other microscopy courses at department D-ERDW are on: - magmatic rocks, following this course in second half of semester (P. Ulmer, IGP; Inst. for Geochemistry and Petrology) - sedimentary rocks (Geol. Institute) - ore minerals (reflected light microscopy, Th. Driesner, IGP) - microstructures, deformed rocks (Geol. Institute)</td>
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</tbody>
</table>

| 651-4047-00L | Microscopy of Magmatic Rocks          | W+   | 2    | 2G    | P. Ulmer  |
| **Abstract** | This course provides basic knowledge in microscopy of igneous rocks. Apart from the identification of common igneous minerals in thin sections, mineral assemblages, textures and structures will be investigated and the results of microscopy will be combined with igneous phase equilbria to understand generation, differentiation and emplacement of igneous rocks. |
| **Objective** | The principal goal of this course is to acquire expertise in: (1) optical determination of minerals in igneous rocks using the polarizing microscope. (2) Identification of igneous rocks basing on modal mineralogy, structure and texture; (3) Interpretation of textures and structures and associated igneous processes; (4) Application of phase diagrams to natural rocks. |
| **Content** | This practical course bases on the course 'Microscopy of metamorphic rocks' (A. Galli), that is taught immediately before this course, where basic knowledge in optical mineralogy and the use of the polarizing microscope is acquired. In this course, the most important (common) igneous minerals and rocks are studied in thin sections under the polarizing microscope. Mineral assemblages, structures, textures and crystalization sequences are determined and utilized to understand the generation, differentiation and emplacement of igneous rocks. In addition, we will apply igneous phase equilibria that have been introduced in other lectures (such as magmatism and metamorphism &II at ETH or an equivalent igneous petrology course) to natural rock samples in order to constrain qualitatively parental magma compositions and crystallization conditions. The range of investigated rocks encompasses mantle rocks, tholeiitic, calc-alkaline and alkaline plutonic and volcanic rocks that contain the most common igneous minerals. |
| **Lecture notes** | Basis of the optical determinations of (igneous) minerals using the polarizing microscope are the tables of Tröger ('Optische Bestimmung der gesteinsbildenden Minerale', Optical determination of rock-forming minerals, 1982) that are available in sufficient number in the class room. Additional notes will be distributed during the lecture. Furthermore, I recommend the lecture notes of H.-G. Stosch (University of Karlsruhe, in German) that can be provided in printed form upon request. |
| **Literature** | There are several good textbooks on the subject of "mineralogy in thin sections" that I can suggest upon request. |
| **Prerequisites / notice** | This course does not include an introduction in optical mineralogy and the use of a polarizing microscope and, therefore, bases on the course "Microscopy of metamorphic rocks" taught by A. Galli immediately before this course where these basic principles are provided. Alternatively, e.g. for external students, an equivalent course is required to follow this practical course. The delivery of 3 acceptably solved homework assignments is acknowledged with an increase of the final grade by 0.25. |

Other microscope courses taught at ETH Zurich at the D-ERDW are:
- Basics of optical mineralogy and petrography (M.W. Schmidt, BSc-course in German)
- Microscopy of metamorphic rocks (A. Galli, prerequisite for this course)
- Sedimentary petrography and microscopy (V. Picotti & M.G. Fellin)
- Reflected Light Microscopy and Ore Deposits Practical (T. Driesner)

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1040 of 2416
Number of participants limited to 19.

**Abstract**
Introduction to reflected light microscopy. Use of the microscope. Identification of opaque minerals through the use of determination tables. Description of textures and paragenetic sequences.

**Objective**
Taking the course in parallel with Ore Deposits I (651-4037-00L) is recommended.

**Content**
Recognition of the most important ore minerals in polished section, interpretation of mineral textures in geological context

**Lecture notes**
To be handed out in class

**Prerequisites / notice**
Credits and mark based on independent description of selected sample(s) towards the end of the course

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**651-4113-00L Sedimentary Petrography and Microscopy**

**Abstract**
Microscopy of carbonate (1st half of semester) and siliciclastic rocks (2nd half) rocks as well as siliceous, phosphatic and evaporitic sediments.

**Objective**
Description of grains and cement/matrix, texture, classification of the main sedimentary rocks. Discussion and interpretation of the environment of sedimentation. Diagenetic Processes.

**Content**
Microscopy of carbonate and siliciclastic rocks, siliceous and phosphatic rocks, their origin and classification. Diagenesis.

**Lecture notes**
English textbooks recommended

**Literature**

**Prerequisites / notice**
The earlier attendance of other MSc microscopy courses (e.g. magmatic and metamorphic rocks) is not required if during the BSc a general course on microscopy of rocks was completed.

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### Part B: Methods

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<tr>
<td>651-4055-00L</td>
<td>Analytical Methods in Petrology and Geology</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>J. Allaz, S. Bernasconi, M. Guillong, L. Zehnder</td>
</tr>
</tbody>
</table>

**Abstract**
Practical work in analytical chemistry for Earth science students.

**Objective**
Knowledge of some analytical methods used in Earth sciences, introduction to data interpretation, writing of a scientific report.

**Content**
Introduction to analytical geochemistry and atom physics, notably:
- X-ray diffraction (XRD),
- X-ray fluorescence analysis (XRF),
- Electron Probe Microanalyzer (EPMA),
- Laser Ablation Inductively Coupled Plasma Mass Spectroscopy (LA-ICP-MS),
- Mass spectroscopy for light isotopes.

**Lecture notes**
Short handouts for each analytical method.

**Fostered competencies**
- Subject-specific Competencies: Techniques and Technologies assessed
- Method-specific Competencies: Analytical Competencies assessed, Problem-solving assessed, Project Management assessed
- Social Competencies: Cooperation and Teamwork assessed
- Personal Competencies: Creative Thinking assessed, Critical Thinking assessed, Integrity and Work Ethics assessed, Self-direction and Self-management assessed

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**651-4117-00L Sediment Analysis**

**Prerequisite: Successful completion of the MSc-course "Sedimentology I" (651-4041-00L).**

**Abstract**
Theoretical background and application of some basic methods for sediment analysis.

**Objective**
The main goal is to learn how to apply the analysis of the texture and grain-size of sediments to constrain the sedimentary processes and environments.

**Content**
A one-day fieldtrip to a local outcrop to learn how to describe sediments in the field and to collect samples for grain-size and compositional analysis. Application of the same analytical techniques on samples of unknown origin: the sampling sites will be revealed at the end of the course. Discussion of the theoretical background and of the results in class. At the end of the course, the student will have to hand in a report with the presentation and discussion of all the data produced during the course.

**Lecture notes**
For the various analytical methods English texts will be provided in class.

**Literature**
Introduction to clastic sedimentology. R.J. Cheel. Brock University

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**651-0046-00L Electron Microscopy Course (SEM and EPMA)**

**Prerequisite: Successful completion of the MSc-course "Sedimentary Petrography and Microscopy" (651-4041-00L).**

**Abstract**
Theory and lab demo of scanning electron microscope (SEM) and electron microprobe analysis (EPMA) applied to geological materials: introduction to the instruments, interaction of electron with matter, electron imaging (SE, BSE, CL), electron backscatter diffraction (EBSD), X-ray analysis for the chemical characterisation of solid material at the micron-scale.

**Objective**
Understand how the instrument works, why it is used, and how the different signals are being generated and analysed. Ability to treat and present analytical results, such as calculating a mineral formula from a mineral analysis.

**Content**
Physical principles of electron microscopy; electron optics, interaction of electrons with matter, production of X-rays, interaction of X-rays with matter, X-rays detection and analysis. The second part of the course includes several demonstrations on various SEMs (at ERDW and Scopem) and one EPMA at DERDW.

**Lecture notes**
Script will be provided, along with copies of the course presentations.

**Literature**
- Reed S.J.B. (1993, second ed.): Electron Microprobe Analysis

[Additional references]
Prerequisites / notice

No prerequisite required beside basic knowledge of petrology and mineralogy. Attending the "Analytical Methods in Geology and Petrology" prior to this course is an advantage.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
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<td>Decision-making</td>
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<td>Critical Thinking</td>
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651-4063-00L X-Ray Powder Diffraction W+ 3 credits 2G M. Plötze

Number of participants limited to 18.

Abstract

In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

Objective

Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data, and
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.

Content

- Fundamental principles of X-ray diffraction
- Setup and operation of X-ray diffractometers
- Interpretation of powder diffraction data
- Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes

Selected handouts will be made available in the lecture

Literature


Prerequisites / notice

The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential.

Software will be provided for future use on own Laptop.

Fostered competencies

Subject-specific Competencies

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<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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Method-specific Competencies

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<th>Media and Digital Technologies</th>
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<th>Project Management</th>
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Social Competencies

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<th>Customer Orientation</th>
<th>Leadership and Responsibility</th>
<th>Self-presentation and Social Influence</th>
<th>Sensitivity to Diversity</th>
<th>Negotiation</th>
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Personal Competencies

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<th>Creative Thinking</th>
<th>Critical Thinking</th>
<th>Integrity and Work Ethics</th>
<th>Self-awareness and Self-reflection</th>
<th>Self-direction and Self-management</th>
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Restricted Choice Modules Geology

A minimum of two restricted choice modules must be completed for the major Geology.

Biogeochemistry

Biogeochemistry: Compulsory Courses

The compulsory courses of the module take place in spring semester.

Biogeochemistry: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>651-4043-00L</td>
<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
</tr>
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</table>

Abstract

The course will focus on biological amd chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.
Objective
- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

Content
- Carbonates: chemistry, mineralogy, biology
- Carbonate sedimentation from the shelf to the deep sea
- Carbonate facies
- Cool-water and warm-water carbonates
- Organic-carbon and black shales
- C-cycle, carbonates, Corg: CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- Marine sediments through geological time
- Carbonates and evaporites
- Lacustrine carbonates
- Economic aspects of limestone

Lecture notes
No script. Scientific articles will be distributed during the course.

Literature
We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems".

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

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<td>651-4057-00L</td>
<td>Climate History and Palaeoclimatology</td>
<td>W+</td>
<td>4</td>
<td>2G</td>
<td>H. Stoll, I. Hernández Almeida, H. Zhang</td>
</tr>
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Abstract
Climate history and palaeoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

Objective
The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lectures on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

Palaeoclimatology
Palaeoclimatology: Compulsory Courses

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Objective
The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.
Content

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

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Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

Palaeoclimatology: Courses of Choice

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<td>Sedimentology II: Biological and Chemical Processes in Lacustrine and Marine Systems</td>
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<td>V. Picotti, A. Gilli, I. Hernández Almeida, H. Stoll</td>
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Abstract

The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

Objective

- You will understand chemistry and biology of the marine carbonate system
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- You will have an overview of marine sedimentation through time

Content

- carbonates; chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, Corg : CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine sediments through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

Lecture notes

no script. scientific articles will be distributed during the course

Literature

We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems"

Prerequisites / notice

The grading of students is based on in-class exercises and end-semester examination.

Sedimentology: Courses of Choice

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<tr>
<td>651-4041-00L</td>
<td>Sedimentology I: Physical Processes and Sedimentary Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Picotti</td>
</tr>
</tbody>
</table>

Abstract

Sediments preserved a record of past landscapes. This courses focuses on understanding the processes that modify sedimentary landscapes with time and how we can read this changes in the sedimentary record.

Objective

The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change. They discuss the advantages and pitfalls of the method and look beyond. In particular we pay attention to introducing the importance of considering entire sediment routing systems and understanding their functioning.

Content

Details of the program will be handed out during the first lecture.

Literature

The sedimentary record of sea-level change
Angela Coe, the Open University.
Cambridge University Press

Prerequisites / notice

The grading of students is based on in-class exercises and end-semester examination.

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-You will be able to relate carbonate mineralogy with facies and environmental conditions
-You will be familiar with cool-water and warm-water carbonates
-You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
-You will be able to use geological archives as source of information on global change
-You will have an overview of marine sedimentation through time

Carbonates; chemistry, mineralogy, biology
Carbonate sedimentation from the shell to the deep sea
Carbonate facies
Cool-water and warm-water carbonates
Organic-carbon and black shales
C-cycle, carbonates, Org.; CO2 sources and sink
Carbonates; their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
Marine sediments through geological time
Carbonates and evaporites
Lacustrine carbonates
Economic aspects of limestone

Objective
-You will understand chemistry and biology of the marine carbonate system
-You will be able to relate carbonate mineralogy with facies and environmental conditions
-You will be familiar with cool-water and warm-water carbonates
-You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
-You will be able to use geological archives as source of information on global change
-You will have an overview of marine sedimentation through time

Content
Carbonates; chemistry, mineralogy, biology
Carbonate sedimentation from the shell to the deep sea
Carbonate facies
Cool-water and warm-water carbonates
Organic-carbon and black shales
C-cycle, carbonates, Org.; CO2 sources and sink
Carbonates; their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
Marine sediments through geological time
Carbonates and evaporites
Lacustrine carbonates
Economic aspects of limestone

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.

Sedimentology: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4901-00L</td>
<td>Quaternary Dating Methods</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>I. Hajdas, M. Christl, S. Ivy Ochs</td>
</tr>
<tr>
<td>Abstract</td>
<td>Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.</td>
<td></td>
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</tr>
<tr>
<td>At the end of the course students will:</td>
<td>1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies. 2. be able to calculate an age based on data of the six methods studied. 3. choose which dating method (or combination of methods) is suitable for a certain field problem. 4. critically read and evaluate the application of dating methods in scientific publications.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>1. Introduction: Time scales for the Quaternary, Isotopes and decay 2. Radiocarbon dating: principles and applications 3. Cosmogenic nuclides: 3He, 10Be, 14C, 21Ne, 26Cl, 36Cl 4. U-series disequilibrium dating 5. Luminescence dating 6. Introduction to incremental: varve counting, dendrochronology and ice cores chronologies 7. Cs-137 and Pb-210 (soil, sediments, ice core) 8. Summary and comparison of results from several dating methods at specific sites</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.</td>
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</tr>
</tbody>
</table>

<p>| 651-4063-00L | X-Ray Powder Diffraction            | W    | 3    | 2G    | M. Plötze     |
| Number       |                                    |      |      |       |               |
| Abstract     | In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters. |      |      |       |               |
| Objective    | Upon successful completion of this course students are able to: - describe the principle of X-ray diffraction analysis - carry out a qualitative and quantitative mineralogical analysis independently, - critically assess the data, - communicate the results in a scientific report. |      |      |       |               |
| Content      | Fundamental principles of X-ray diffraction Setup and operation of X-ray diffractometers Interpretation of powder diffraction data Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis) |      |      |       |               |
| Lecture notes | Selected handouts will be made available in the lecture |      |      |       |               |
| Prerequisites / notice | The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data. Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential. Software will be provided for future use on own Laptop. |      |      |       |               |</p>
<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>not assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
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<td></td>
<td>Leadership and Responsibility</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td>Sensitivity to Diversity</td>
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<td></td>
<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>W</th>
<th>credits</th>
<th>G</th>
<th>Instructor(s)</th>
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<tbody>
<tr>
<td>651-4341-00L</td>
<td>Source to Sink Sedimentary Systems</td>
<td>3</td>
<td>2G</td>
<td>T. I. Eglinton, J. Hemingway, L. Bröder, S. Dötterl</td>
<td></td>
</tr>
</tbody>
</table>

**Abstract**

The transfer and redistribution of mass and chemical elements at the Earth’s surface is controlled by a wide range of processes that will affect the magnitude and nature of fluxes exported from continental fluvial systems. This course addresses the production, transport, and deposition of sediments from source to sink and their interaction with biogeochemical cycles.

**Objective**

This course aims at integrating different earth science disciplines (geomorphology, geochemistry, and tectonics) to gain a better understanding of the physical and biogeochemical processes at work across the sediment production, routing, and depositional systems. It will provide insight into how it is actually possible to “see a world in a grain of sand” by taking into account the cascade of physical and chemical processes that shaped and modified sediments and chemical elements from their source to their sink.

**Content**

Lectures will introduce the main source to sink concepts and cover physical and biogeochemical processes in upland, sediment producing areas (glacial and periglacial processes; mass movements; hillslopes and soil processes/development; critical zone biogeochemical processes).

Field excursion (3 days, 30 September - 2 October 2022): will cover the upper Rhône from the Rhône glacier to the Rhône delta in Lake Geneva as small scale source-to-sink system.

Practicals comprise (I) a small autonomous project on the Rhône catchment based on samples collected during the field trip and (II) an independent report on how you would design, build, and implement your own source-to-sink study.

Lecture notes are provided online during the course. They summarize the current subjects week by week and provide the essential theoretical background.

Suggested references:

- *Sediment routing systems: the fate of sediments from Source to Sink* by Philip A. Allen (Cambridge University Press)
- *Principles of soilscape and landscape evolution by Garry Willgoose* (Cambridge University Press)
- *Geomorphology, the mechanics and chemistry of landscapes* by Robert S. Anderson & Suzanne P. Anderson (Cambridge University Press)

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<tr>
<td>651-4243-00L</td>
<td>Seismic Stratigraphy and Facies</td>
<td>2</td>
<td>3G</td>
<td>G. Eberli</td>
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</tr>
</tbody>
</table>

**Abstract**

The course teaches the techniques of seismic interpretation for solving geological and environmental problems. A special focus is given to the seismic facies analysis and seismic sequence stratigraphy of different depositional systems. In addition, examples are presented how seismic data can be integrated into research projects in basin analysis, paleoceanography and paleoclimatology.

**Objective**

1. Acquire techniques for a comprehensive interpretation of seismic sections for solving geologic, stratigraphic and environmental problems
2. Correlation of seismic facies and seismic attributes to lithologic facies in different sedimentary systems
3. Learn the principles and techniques of seismic sequence stratigraphy and the differences between lithostratigraphy and sequence stratigraphy
4. Learn to integrate seismic data into paleoceanographic and paleoclimatic research.
Day 1:
Introduction seismic facies analysis with exercise
Seismic resolution
Seismic facies of contourite drift systems and their value as physical indicators of global current changes.

Day 2:
Seismic attributes and seismic geomorphology
Siliciclastic deltas, shelves and turbidite systems, 2D-3D
Exercise: Seismic section Tarragon Basin and reconstructing the basin evolution with respect to the climate conditions at the end of the Miocene.
Seismic facies carbonate systems
Carbonates as recorders of sea level and paleoclimate
Deepwater environments, including cold-water coral habitats

Day 3:
Carbonates versus volcanic seismic facies
Introduction seismic attributes
Faults and structures on seismic sections
Seismic facies of mixed systems with exercises from Canada and the Paradox Basin

Day 4:
Sea level and sedimentation
Telling ages on seismic section
Seismic stratigraphy and sequence stratigraphy
Exercise: Sequence analysis Straits of Andros
Final discussion

Lecture notes
An original script (110 pages) designed for the class will be distributed at the beginning of the course.

Literature
Books

Prerequisites / notice
Basic knowledge in sedimentology and stratigraphy
Objective

The objective of this course is to introduce rock physics and rock deformation, and discuss the aid of laboratory tests to interpretation at large scale.

Rock Physics provides the understanding to connect geomechanical and geophysical data to the intrinsic properties of rocks, such as mineral composition and texture. Rock Physics is a key component in geo-resources exploration and exploitation, and in geo-hazard assessment.

For rock deformation we will illustrate how to determined flow-laws of rocks from experiments and how to extrapolate to natural conditions. Since the time scale of laboratory experiments is several orders of magnitude faster than nature, we will compare the microstructure of natural rocks with that produced during the experiments to prove that the same mechanisms are operating.

For this purpose, the fundamental techniques of experimental rock deformation will be illustrated and test on natural rock samples in the plastic deformation regime (high temperature) as well as brittle regime (room temperature) will be presented. We will perform tests in the lab to acquire the data, to correct for calibration and to process the data and finally to interpret the data.

The course is at Master student level, but will be useful for PhDs students who want to begin to work in experimental deformation or who want to know the meaning and the limitation of laboratory flow-laws for geodynamic modelling.

Content

The course will focus on research-based term project, lectures will alternate with laboratory demonstrations.

We will illustrate how intrinsic properties of rocks (mineral composition, porosity, pore fluids, crystallographic orientation, microstructures) are connected to the following physical properties:

- permeability;
- elastic properties for seismic interpretations;
- anisotropy of the above physical properties.

We will measure some of those parameters in laboratory and discuss real case studies and applications.

Prerequisites / notice

The course of Structural Geology (651-3422-00L) is highly recommended before attending this course.

Moreover the students should have basic knowledge in geophysics and mineralogy/crystallography.

In doubt, please contact the course responsible beforehand.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>651-3521-00L</td>
<td>Tectonics</td>
<td></td>
<td>3</td>
<td>2V</td>
<td>W. Behr, S. Willett</td>
</tr>
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</table>

### Open Choice Modules Geology

#### Basin Analysis

#### Basin Analysis: Compulsory Courses

<table>
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Abstract

The transfer and redistribution of mass and chemical elements at the Earth’s surface is controlled by a wide range of processes that will affect the magnitude and nature of fluxes exported from continental fluvial systems. This course addresses the production, transport, and deposition of sediments from source to sink and their interaction with biogeochemical cycles.

Objective

This course aims at integrating different earth science disciplines (geomorphology, geochemistry, and tectonics) to gain a better understanding of the physical and biogeochemical processes at work across the sediment production, routing, and depositional systems. It will provide insight into how it is actually possible to “see a world in a grain of sand” by taking into account the cascade of physical and chemical processes that shaped and modified sediments and chemical elements from their source to their sink.
Content
Lectures will introduce the main source to sink concepts and cover physical and biogeochemical processes in upland, sediment producing areas (glacial and periglacial processes; mass movements; hillslopes and soil processes/development; critical zone biogeochemical processes).

Field excursion (3 days, 30 September - 2 October 2022): will cover the upper Rhône from the Rhône glacier to the Rhône delta in Lake Geneva) as small scale source-to-sink system.

Practicals comprise (I) a small autonomous project on the Rhône catchment based on samples collected during the field trip and (II) an independent report on how you would design, build, and implement your own source-to-sink study.

Lecture notes
Lecture notes are provided online during the course. They summarize the current subjects week by week and provide the essential theoretical background.

Literature
Suggested references:
- “Sediment routing systems: the fate of sediments from Source to Sink” by Philip A. Allen (Cambridge University Press)
- “Principles of soilscape and landscape evolution by Garry Willgoose” (Cambridge University Press)
- “Geomorphology, the mechanics and chemistry of landscapes” by Robert S. Anderson & Suzanne P. Anderson (Cambridge University Press)

Basin Analysis: Courses of Choice

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<td>W+</td>
<td>2</td>
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Abstract
The course teaches the techniques of seismic interpretation for solving geological and environmental problems. A special focus is given to the seismic facies analysis and seismic sequence stratigraphy of different depositional systems. In addition, examples are presented how seismic data can be integrated into research projects in basin analysis, paleoceanography and paleoclimatology.

Objective
1. Acquire techniques for a comprehensive interpretation of seismic sections for solving geologic, stratigraphic and environmental problems
2. Correlation of seismic facies and seismic attributes to lithologic facies in different sedimentary systems
3. Learn the principles and techniques of seismic sequence stratigraphy and the differences between lithostratigraphy and sequence stratigraphy
4. Learn to integrate seismic data into paleoceanographic and paleoclimatic research.

Content
The four day course consists of lectures that are accompanied by a variety of exercises.

Day 1:
Introduction seismic facies analysis with exercise
Seismic facies of contourite drift systems and their value as physical indicators of global current changes.

Day 2:
Seismic attributes and seismic geomorphology
Siliciclastic deltas, shelves and turbidite systems, 2D-3D
Exercise: Seismic section Tarragon Basin and reconstructing the basin evolution with respect to the climate conditions at the end of the Miocene.
Seismic facies carbonate systems
Carbonates as recorders of sea level and paleoclimate
Deepwater environments, including cold-water coral habitats

Day 3:
Carbonates versus volcanic seismic facies
Introduction seismic attributes
Faults and structures on seismic sections
Seismic facies of mixed systems with exercises from Canada and the Paradox Basin
Telling ages on seismic section
Seismic stratigraphy and sequence stratigraphy
Exercise: Sequence analysis Straits of Andros

Day 4:
Sea level and sedimentation
Seismic stratigraphy and sequence stratigraphy
Exercise: Sequence analysis Straits of Andros
Final discussion

Lecture notes
An original script (110 pages) designed for the class will be distributed at the beginning of the course.

Literature
Books Seismic Interpretation of Depositional Systems:

Prerequisites / notice
Basic knowledge in sedimentology and stratigraphy

Earthquake Seismology

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1049 of 2416
This course is a general introduction to the methods of seismic hazard analysis. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties.

In the course it is explained how the disciplines of seismology, geology, strong-motion geophysics, and earthquake engineering contribute to the evaluation of seismic hazard. It provides an overview of the input data and the tools in deterministic and probabilistic seismic hazard assessment, and discusses the related uncertainties. The course includes the discussion related to Intensity and macroseismic scales, historical seismicity and earthquake catalogues, ground motion parameters used in the seismic hazard assessment, definitions of the seismic risk assessment, and discusses the related uncertainties.

During the course recent earthquakes and their impacts are discussed and related to existing hazard assessments for the areas of interest.

If you're interested in knowing more about the relationship between seismicity and plate tectonics, this is the course for you. (If you're not interested, but your program of study requires that you complete this course, this is also the course for you.)

The aim of the course is to obtain a basic understanding of the physical process behind earthquakes and their basic mathematical description. By the conclusion of this course, we hope that you will be able to:

- explain earthquake source representations of varying complexity;
- address earthquakes in the context of different tectonic settings;
- explain the statistical behaviour of global earthquakes;
- describe and connect the ingredients for a seismotectonic study

Topics covered in the course include:

- review of stress and deformation in the Earth, stress and strain tensors, rheology and failure criteria, fault stresses, friction and effects of fluids
- earthquake focal mechanisms; relationship between stress fields and focal mechanisms;
- seismic moment and moment tensors;
- crustal deformation from seismic, geologic, and geodetic observations;
- earthquake stress drop, scaling, and source parameters;
- global earthquake distribution; current global earthquake activity;
- different seismotectonic regions; examples of earthquake activity in different tectonic settings.

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018.

The course will be evaluated in a final written test covering the topics discussed during the lectures.

The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS.

The course will be given in English.

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### Geomagnetics

Courses are only offered in spring semester.

### specializations

Earthquake Seismology: Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>651-4021-00L</td>
<td>Engineering Seismology</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>D. Fäh, M. Koroni</td>
</tr>
</tbody>
</table>

#### Objective

This course is a general introduction to the methods of seismic hazard analysis.

#### Content

In the course it is explained how the disciplines of seismology, geology, strong-motion geophysics, and earthquake engineering contribute to the evaluation of seismic hazard.

#### Literature


Basic knowledge of continuum mechanics and rock mechanics, as well as notion of tensor analysis is strongly suggested. We recommend to have taken the course Continuum Mechanics (generally taught during the Fall semester).

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018.

The course will be evaluated in a final written test covering the topics discussed during the lectures.

The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS.

The course will be given in English.

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### Geographic Information Systems: Compulsory Courses

The courses of this module are offered by UZH and must be registered at UZH.

#### Geographic Information Systems: Courses of Choice

Courses are only offered in spring semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>651-4901-00L</td>
<td>Quaternary Dating Methods</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>I. Hajdas, M. Christl, S. Ivy Ochs</td>
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</table>
Abstract
Reconstruction of time scales is critical for all Quaternary studies in both Geology and Archaeology. Various methods are applied depending on the time range of interest and the archive studied. In this lecture, we focus on the last 50 ka and the methods that are most frequently used for dating Quaternary sediments and landforms in this time range.

Objective
Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

At the end of the course students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. be able to calculate an age based on data of the six methods studied.
3. choose which dating method (or combination of methods) is suitable for a certain field problem.
4. critically read and evaluate the application of dating methods in scientific publications.

Content
1. Introduction: Time scales for the Quaternary, Isotopes and decay
2. Radiocarbon dating: principles and applications
3. Cosmogenic nuclides: 3He, 10Be, 14C, 21Ne, 26Cl, 36Cl
4. U-series disequilibrium dating
5. Luminescence dating
6. Introduction to incremental: varve counting, dendrochronology and ice cores chronologies
7. Cs-137 and Pb-210 (soil, sediments, ice core)
8. Summary and comparison of results from several dating methods at specific sites

Prerequisites / notice
Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.
Visit to Limno Lab and sampling a sediment core
Optional (individual): 1-5 days hands-on radiocarbon dating at the C14 lab at ETH Hoenggerebrg

Required: attending the lecture, visiting laboratories, handing back solutions for problem sets (Exercises)
Erosion and sedimentation by glaciers as a function of topography, englacial temperature, sediment balance, sliding and melt water runoff.

Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with

Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of

University lecturers

Communication

Copies/pdf of scientific papers will be distributed during the course (moodle interface)

After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature.

Selected topics of scientific research in Glaciology

The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a

In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

Selected topics of scientific research in Glaciology

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Fostered competencies

Method-specific Competencies

651-4077-00L

Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO815

Mind the enrolment deadlines at UZH:

https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.

Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).

Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes

651-4101-00L

Physics of Glaciers

Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Will be provided on Moodle

A list of relevant literature is available on Moodle

High-school mathematics and physics knowledge required.

651-4077-00L

W 3 credits 1V

University lecturers

651-4101-00L

W 3 credits 3G

M. Lüthi, F. T. Walter, M. Werder

101-0289-00L

Applied Glaciology

The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

The objectives of the courses are to:

- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

W 4 credits 2G

D. Farinotti, A. Bauder, M. Werder

Mind the enrolment deadlines at UZH:

https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes

University lecturers

Physics of Glaciers

Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

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The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Will be provided on Moodle

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High-school mathematics and physics knowledge required.

Applied Glaciology

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The objectives of the courses are to:

- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.
Content

The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Lecture notes

Digital lecture handouts will be distributed prior to each class.

Literature

Links to relevant literature will be provided during the classes.

Prerequisites / notice

Completed BSc studies. Basic knowledge in computer scripting in any language (e.g. Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.

Fostered competencies

Subject-specific Competencies

Concepts and Theories
Techniques and Technologies

Method-specific Competencies

Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies

Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies

Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Lithosphere Structure and Tectonics

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<tr>
<td>651-3521-00L</td>
<td>Tectonics</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>W. Behr, S. Willett</td>
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</table>

Abstract

Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales. Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Objective

Comprehensive understanding of evolution, mechanics, and rheology of divergent, convergent and wrenching tectonic systems from the lithospheric scale to local shallow crustal and outcrop-scales.
Assessment of mechanisms responsible for plate movements (the Earth as a heat transfer machine, dynamics of earth mantle, plate driving forces) and subsequent large-scale structures (oceanic basins and cycle of the oceanic lithosphere, convergence and mountain systems and continental growth, etc) through theoretical and experimental information.
Evaluation of plate tectonic and other orogenic processes through the study of reference examples of taken in Alps-Himalaya orogenic system.

Content

Plate tectonic frame work: earth cooling and mantle-plate interaction, three kinds of plate boundaries and their roles and characteristics, cycle of oceanic lithosphere, longevity and growth of continents, supercontinents.
Rheology of layered lithosphere and upper mantle.
Obduction systems
Collisions systems
Extensional systems
Basin evolution
Passive and active continental margin evolution

Literature


Palaeontology

Palaeontology: Compulsory Courses

The compulsory courses take place in spring semester.

Palaeontology: Courses of Choice

The courses of choice are offered by UZH and must be registered at UZH.

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<tr>
<td>651-1380-00L</td>
<td>Paleontological Excursions on Weekends (University of Zürich)</td>
<td>W</td>
<td>1 credit</td>
<td>1P</td>
<td>University lecturers</td>
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No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO279
Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with Quaternary Dating Methods

University lecturers

Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of the fundamental principles of the most frequently used dating methods for Quaternary studies.

Students will be made familiar with the details of the six dating methods through lectures on basic principles, analysis of case studies, solving of problem sets for age calculation and visits to dating laboratories.

At the end of the course students will:
1. understand the fundamental principles of the most frequently used dating methods for Quaternary studies.
2. be able to calculate an age based on data of the six methods studied.
3. choose which dating method (or combination of methods) is suitable for a certain field problem.
4. critically read and evaluate the application of dating methods in scientific publications.

Visit to radiocarbon lab, cosmogenic nuclide lab, accelerator (AMS) facility.

Required: attending the lecture, visiting laboratories, handing back solutions for problem sets (Exercises)

Remote Sensing and Geographic Information Science

Remote Sensing: Courses of Choice

Remote Sensing: Compulsory Courses

Remote Sensing: Courses of Choice
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<tr>
<td>651-4269-00L</td>
<td>Specialisation in Remote Sensing: Spectroscopy of the Earth System</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>University lecturers</td>
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<td>UZH Module Code: GEO442</td>
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<td>Prerequisite: Remote Sensing Methods (UZH Module Code: GEO371)</td>
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<tr>
<td>651-4257-00L</td>
<td>Specialisation in Remote Sensing: SAR and LIDAR (University of Zurich)</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>University lecturers</td>
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Shallow Earth Geophysics

Courses are only offered in spring semester.

Modules from the Engineering Geology Major

Choice from Engineering Geology Required Modules

Modules from the Geophysics Major

Choice from Geophysics Compulsory Modules

Choice from Geophysics Restricted Choice Modules

Modules from the Mineralogy and Geochemistry Major

Choice from the Mineralogy and Geochemistry Restricted

Choice Modules

Modules from the Major Geology Restricted Choice Modules

Choice from the Geology Restricted Choice Modules

Major in Engineering Geology

Compulsory Modules Engineering Geology

Engineering Geology: Fundamentals

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<th>Number</th>
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<tr>
<td>651-4025-00L</td>
<td>Rock Mechanics and Rock Engineering</td>
<td>O</td>
<td>4</td>
<td>4V</td>
<td>Q. Lei, L. de Palézieux dit Falconnet, P. A. Selvadurai</td>
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<td>Abstract</td>
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<td>and rock engineering (e.g. tunnelling,</td>
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<td>rock slope stability).</td>
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<td>rock mechanics and generic rock</td>
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<td>engineering. The student shall</td>
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<td>understand how rocks behave at</td>
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<td>The link between rock mechanics,</td>
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<td>the rock formed) will be clearly</td>
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<td>established. The student shall</td>
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<td>understand basic principles of rock</td>
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<td>mechanics and rock engineering. In</td>
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<td>addition, the student shall learn</td>
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<td>how to apply the results from lab</td>
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<td>and field investigations to simple</td>
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<td>engineering problems. This knowledge</td>
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<td>integration courses (Landslide</td>
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<td>Analysis and Hazard Mitigation;</td>
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<td>Engineering Geology of Underground</td>
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<td>Excavations).</td>
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<td>Content</td>
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<td>and generic rock engineering. The</td>
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<td>course is compulsory for the MSc</td>
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<td>Eng Geol. The applications of rock</td>
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<td>mechanical principles and rock</td>
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<td>engineering methods are extensively</td>
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<td>covered in subsequent courses.</td>
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<td>Lecture notes</td>
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<td>available on our homepage:</td>
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<tr>
<td>651-4033-00L</td>
<td>Soil Mechanics and Foundation Engineering</td>
<td>O</td>
<td>4</td>
<td>3V</td>
<td>Q. Lei, M. Stolz</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Understanding the principles of</td>
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<td>soil behaviour and the fundamentals</td>
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<td>of geotechnical practices in soils.</td>
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<td>geotechnical engineers.</td>
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<td>Soil Mechanics:</td>
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<td>Fundamental concepts of strength</td>
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<td>and deformation of different soils.</td>
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<td>Introduction to geotechnical</td>
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<td>Significance of (ground)water</td>
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<td>Geotechnical Engineering in Soils:</td>
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<td>Evaluation of geotechnical scenarios,</td>
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<td>relation of soil properties and soil</td>
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<td>composition, interactions</td>
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<td>between soil and building,</td>
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<td>standard construction methods in</td>
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<td>and levees), requirements for the</td>
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<td>geotechnical prognosis</td>
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</table>
This lecture is supported by the textbook: "Geotechnical Engineering" by Donald P. Coduto, 2nd edition, 2011; ISBN-13: 978-0-13-135425-8

Prerequisites / notice

Courses must be completed:
- Introduction to Engineering Geology (BSc level)
- Introduction to Groundwater
- Sedimentology and Quaternary deposits
- Principles of Physics

Courses recommended:
- Eng Geol Site Investigations
- Eng Geol Field Course I (soils)
- Clay Mineralogy

651-4023-00L Groundwater O 4 credits 4G X.-Z. Kong, B. Marti

Abstract

The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, formulating, and solving groundwater flow and solute transport problems.

Objective

a) Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions.

b) Students are able to formulate simple, practical groundwater flow and solute transport problems.

c) Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems.

Content

1. Introduction to groundwater problems. Concepts to quantify properties of aquifers.

2. Flow equation. The generalised Darcy law.

3. The water balance equation and basic concepts of poroelasticity.


5. Analytical solutions to flow problems

6. Finite difference scheme solution for simple flow problems.


10. Analytical solutions to transport problems.

11. Fractured and karst aquifers.

12. The unsaturated zone and capillary pressure.

13. Examples of applied hydrogeology from Switzerland and around the world. (Given by Dr. Beatrice Marti from Hydrosolutions Ltd.)

Lecture notes

Handouts of slides.

Literature


de Marsily G., Quantitative Hydrogeology, Academic Press, 1986

651-4125-00L Rock and Soil Mechanical Lab Practical O 3 credits 2P L. de Palézieux dit Falconnet, C. Madonna, L. Nibourel

Abstract

In this course, students will gain hands on experience performing laboratory and index tests commonly used in Rock and Soil Mechanics. The course is divided into two modules, with half the semester devoted to rock mechanic testing, and half to soil mechanics testing.

Objective

This course introduces the fundamentals of laboratory testing of rock and soil. Students will learn how to interpret laboratory data, the expected accuracy and limitations of common laboratory tests and the most appropriate testing method(s) for a given problem.

Content

In the Rock Mechanics lab, the following laboratory tests are performed: Ultrasonic velocity measurements, Point load test, Brazilian tensile test, Uniaxial compression test, Triaxial compression test. Through performing these experiments, students will get familiar with stress-strain curves, tensile, unconfined, and confined strength of rocks, Young’s modulus and Poisson ratio, and finally cohesion and friction angle of intact rocks.

In the Soil Mechanics Lab, the following seven laboratory tests are performed: Sieve Analysis, Hydrometer Analysis, Atterberg Limits, Proctor Compaction, Direct Shear Test, Falling Head Permeability and Consolidation Test. Through performing these tests, students gain an understanding of the relationship between index properties and soil behavior, as well as the strength, deformability and hydraulic characteristics of soils.

Lecture notes

Course materials are available on moodle

Prerequisites / notice

Attendance of the following (or similar) courses:
- 651-4025-00L Rock Mechanics and Rock Engineering
- 651-4033-00L Soil Mechanics and Foundation Engineering

651-4065-00L Geological Site Investigations O 3 credits 3G M. Ziegler

Abstract

This course introduces students to the methods used in characterising, developing or monitoring geotechnical engineering project sites. Measurements, tools and analyses are described that are relevant to determining the geologic conditions at a site as well as deformations that occur under natural or construction conditions.
Objective

This course aims at introducing the general procedures taken during an engineering geological site investigation. Students who complete the course should be able to design a site investigation program of measurements based on information from initial desk studies, and to analyse, integrate and interpret data from the measurement program.

Content

The methods that are routinely employed in site investigations will be described focusing on their applicability in different geologic environments. The limitations of the data in constraining the parameters of interest will be addressed together with problems of interpretation and cost-versus-information value. Specific topics addressed include drilling, coring, sampling, borehole testing, geophysical methods used in engineering geology, satellite, air- and ground-based surface and displacement monitoring (photogrammetry, LIDAR and Radar), and in-situ deformation measurement methods.

Lecture notes

Lecture notes will be available for download 1-2 days before each class.

Literature


Supplemental literature will be suggested and made available during the course.

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management not assessed

Social Competencies

Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies

Adaptability and Flexibility assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management not assessed

Engineering Geology: Integration

Courses for this Module take place in spring semester.

Engineering Geology: Industrial Internship

Number Title Type ECTS Hours Lecturers
651-4071-00L Industrial Internship I O 12 credits external organisers

Prerequisites: successful participation in all 3 compulsory modules of the Major in Engineering Geology (Fundamentals, Methods and Integration).

The Industrial Internship of the Eng Geol Major takes place in the second MSc year after consultation with Dr. Heike Willenberg. Detailed regulations of this practical are published on the Engineering Geology Website.

Abstract

The industry practical is supervised both from the industry partner and ETH and consists of technically and/or scientifically challenging work in the engineering geology domain. The regular duration of the practical is 10 weeks. The practical is is pre-defined in a work plan and concluded with a report written by the student.

Objective

The goals of the industry practical are to become familiar with technical, economic, legal and communication issues of real-life work in private industry or technical administration.

Major in Geophysics

Compulsory Modules Geophysics

Geophysics: Methods I

Number Title Type ECTS Hours Lecturers
651-4005-00L Geophysical Data Processing W+ 3 credits 2G C. V. Cauzzi, L. Ermert

Abstract

This course presents fundamental digital signal processing and filter theory with a focus on geophysical applications.

Objective

The goal of the course is to provide an understanding of the principles of digital signal processing and filter theory. Form: two hours lecture with two hours of computer based exercises per week over 7 weeks.

Content

Analog-digital conversion: dynamic range and resolution; Dirac-impulse, step function; Laplace transformation; Z-transformation; Differential equations of linear time-invariant systems; Examples: seismometer and RC-filter; Impulse response and transfer function; Frequency selective filters: example Butterworth filters; Digital filters: impulse invariance and bilinear transformation; Inverse filters; Response spectra.

Lecture notes

Lecture notes will be made available for download from the website of the course.

Literature

The class follows no single book. A list of relevant texts will be given in class.
This course aims to provide the students with a general introduction of the fundamental concepts of fluid dynamics such as viscous flows, 

Continuum Mechanics

T. Gerya

Title

Hours

651-4241-00L

Numerical Modelling I and II: Theory and Applications

W+

6 credits

4G

T. Gerya

Abstract

In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasise a hands-on learning approach rather than extensive theory.

Objective

The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.

Content

A provisional week-by-week schedule (subject to change) is as follows:

- Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.
- Week 3: Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.
- Weeks 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.
- Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.
- Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.
- Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.
- Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.
- Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.

GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature


Geophysics: Methods II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4001-00L</td>
<td>Introduction to Fluid Dynamics</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>J. A. R. Noir</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course aims to provide the students with a general introduction of the fundamental concepts of fluid dynamics such as viscous flows, potential flows, instabilities. The course is a combination of lectures, exercises and demo experiments.</td>
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<tr>
<td>Objective</td>
<td>The lectures are a mix of table top experiments, everyday observations and theoretical derivations.</td>
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</tbody>
</table>
| Content | 1)Fundamentals of fluid mechanics.
| | 2)Ideal inviscid fluids.
| | 3)Incompressible viscous fluids.
| | 4)Heat transfer in fluids |
| Lecture notes | The slides of last year presentations will be made available at the beginning of the semester, they may be subject to changes during the lectures. |

| 651-4007-00L | Continuum Mechanics | W+ | 3    | 2V    | T. Gerya |
| Abstract | In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth's mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications. |
| Objective | The goal of this course is to learn and understand few principal partial differential equations (conservation laws) that are applicable for analysing and modelling of any continuum including the Earth's mantle, core, atmosphere and ocean. By the end of the course, students should be able to write, explain and analyse the equations and apply them for simple analytical cases. Numerical solving of these equations will be discussed in the Numerical Modelling I and II course running in parallel. |
A provisional week-by-week schedule (subject to change) is as follows:

Weeks 1-2: The continuity equation
Exercise: Computing the divergence of velocity field.

Weeks 3-4: Density and gravity
Exercises: Computing density, thermal expansion and compressibility from an equation of state. Derivation of gravitational acceleration and its divergence from gravitational potential.

Weeks 5-6: Stress and strain
Exercises: Analysing strain rate tensor for solid body rotation. Computing stress invariants

Weeks 7-8: The momentum equation

Week 9: Viscous rheology of rocks
Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth's interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws.
Exercise: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Week 10-11: The heat conservation equation

Week 12-13: Elasticity and plasticity
Exercise: Compose viscoelastic stress evolution.


Lecture notes
GRADING will be based on homeworks (1/3) and oral exam (2/3).
Script and Exam questions are available by request tgerya@ethz.ch

Literature

651-4130-00L Mathematical Methods W+ 3 credits 2G A. Kuvshinov, M. Maitra

Abstract
The course guides students in learning mathematical machinery used to solve various physical problems. Special attention is paid to the analytical methods to solve partial differential equations describing physical processes such as heat transfer, electromagnetic induction, wave propagation, among others.

Objective
The goal of this course is to refresh and deepen students' knowledge in mathematical methods relevant to the problems arising in solid Earth physics.

Content
The provisional subjects covered in this course are as follows:
(i) Vector calculus, vector identities, Parametric Curves and Surfaces
(ii) Calculus in curvilinear coordinates, Spherical and Cylindrical bases
(iii) Partial Differential Equations, Laplace equation, Helmholtz equation, Separation of variables, eigenvalues and eigenfunctions, spherical harmonic analysis
(iv) Special functions: Delta function, Heaviside function, Bessel functions, Green's functions
(v) Tensors, Einstein notation, tensor algebra
Note: The actual content of the course may have slight deviations from the stated list.

Lecture notes
Current lecture notes and homeworks will be found during the course at www.polybox.ethz.ch

Literature
1. E. Kreyszig, "Advanced engineering mathematics"
2. M. Boas, "Mathematical methods in the physical sciences"
3. K.F. Riley, M. P. Hobson, J. Bence, "Mathematical methods for physics and engineering"
4. R. Snieder, "A guided tour of mathematical methods for the physical sciences"

Seismology

651-4014-00L Seismic Waves II W+ 3 credits 2G T. Diehl, F. Lanza, M. D. P. Sánchez Sánchez-Pastor

Abstract
This course provides an overview on the most widely used seismological methods to image the Earth's interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body-wave and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.

Objective
Understand the strengths and weaknesses of various active and passive tomographic methods to image the structure of the Earth.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1059 of 2416
A. P. Rinaldi
Lecturers

Course notes will be made available on a designated course web site. Most of the topics discussed in the course are available in the book If you're interested in knowing more about the relationship between seismicity and plate tectonics, this is the course for you. (If you're not

ECTS

This course is a general introduction to the methods of seismic hazard analysis. Slides and scripts will be posted on Moodle.

The goal of this course is to enable students to understand current knowledge and uncertainties regarding the formation, structure, dynamics and evolution of planetary bodies in our solar system and also apply it to ongoing discoveries regarding planets around other stars.

This course will be taught in fall 2017 and it will be followed by Earthquakes 2: Source Physics in Spring 2018.

The course will be worth 3 credit points, and a satisfactory total grade (4 or better) is needed to obtain 3 ECTS.

The course will be given in English.

<table>
<thead>
<tr>
<th>651-4015-00L</th>
<th>Earthquakes I: Seismotectonics</th>
<th>W+</th>
<th>3 credits</th>
<th>2G</th>
<th>A. P. Rinaldi, T. Diehl</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>The aim of the course is to obtain a basic understanding of the physical process behind earthquakes and their basic mathematical description. By the conclusion of this course, we hope that you will be able to:</td>
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<td></td>
<td>- describe the relationship between earthquakes and plate tectonics in a more sophisticated and complete way</td>
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<td>- explain earthquake source representations of varying complexity;</td>
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<td>- address earthquakes in the context of different tectonic settings;</td>
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<td>- explain the statistical behaviour of global earthquakes</td>
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<td>- describe and connect the ingredients for a seismotectonic study</td>
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<tr>
<td><strong>Content</strong></td>
<td>The course features a series of 14 meetings, in which we review some fundamentals of continuum mechanics and tensor analysis required for a complete understanding of the relation between earthquakes and plate tectonics. Our goal is to help you understand deformation the small scale (fault) to the scale of plate tectonics. We will tell you about several ways to represent an earthquake source; we'll present these in order of increasing sophistication. You will enjoy (at least) a computer/class exercise and a guest lecture.</td>
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<td>Topics covered in the course include:</td>
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<tr>
<td></td>
<td>review of stress and deformation in the Earth, stress and strain tensors, rheology and failure criteria, fault stresses, friction and effects of fluids</td>
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<td>earthquake focal mechanisms; relationship between stress fields and focal mechanisms; seismic moment and moment tensors;</td>
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<td>crustal deformation from seismic, geologic, and geodetic observations; earthquake stress drop, scaling, and source parameters;</td>
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<td>global earthquake distribution; current global earthquake activity; different seismotectonic regions; examples of earthquake activity in different tectonic settings.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Course notes will be made available on a designated course web site. Most of the topics discussed in the course are available in the book mentioned below.</td>
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</table>
The compulsory courses take place in spring semester.

**Microscopy Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>651-4028-00L</td>
<td>Physical Properties of Minerals</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Spiekermann, P. Saha</td>
</tr>
</tbody>
</table>

Abstract

Physical properties of minerals, e.g. electrical properties, elastic properties are discussed. The effect of the crystal symmetry on the symmetry of physical properties as well as the mathematical formulation of the physical properties are major topics.

<table>
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<tr>
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<th>ECTS</th>
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</tr>
</thead>
<tbody>
<tr>
<td>651-4039-00L</td>
<td>Thermodynamics Applied to Earth Materials</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Connolly</td>
</tr>
</tbody>
</table>

Abstract

This course develops the thermodynamic concepts necessary to predict phase equilibria and to compute physical properties from thermodynamic data.

Objective

To provide students with the conceptual and practical skills necessary to implement thermodynamic models and data as provided in the earth science literature. The computer software package Maple is relied upon to allow students to solve realistic problems without the distraction of mathematical details.

Content

Elementary concepts (1st and 2nd Laws; composition, state and extent); stability criteria; Legendre transforms; Maxwell relations and other manipulations of thermodynamic functions; calculation of Gibbs energy for a pure solid; simple solution models; order-disorder solution models; reciprocal solution models; equations of state for molecular fluids; free energy minimization.

This course is neither an introduction to computer methods for calculating petrological phase equilibria nor an introduction to phase diagram methods.

Prerequisites / notice

The grade for the course is based on exercises assigned as homework. Some familiarity with elementary thermodynamics (phase rule, reactions) and mathematics (differentiation, integration) is assumed. Experience with Maple or comparable programs such as Mathematica is helpful.

**X-Ray Powder Diffraction**

Number of participants limited to 18.

Abstract

In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

Objective

- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

Content

Fundamental principles of X-ray diffraction

Setup and operation of X-ray diffractometers

Interpretation of powder diffraction data

Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes

Selected handouts will be made available in the lecture

Literature


Prerequisites / notice

The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential. Software will be provided for future use on own Laptop.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1061 of 2416
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

651-4233-00L Composition and Evolution of the Earth and Planets

Abstract
In this Masters-level course, we address the formation and evolution of the rocky planets with a particular focus on the chemical and isotopic make-up of the Earth and its mantle. This is achieved through analysis of its partial melting products in different tectonic settings and through time.

Objective
Students will gain an insight into cutting-edge research in planetary science and the geochemical evolution of Earth's mantle. The objective is to be able to synthesise scientific studies whose conclusions differ, and, eventually, to form a coherent opinion by debating and scrutinising the available data. This will be achieved by weekly lectures and exercises throughout the semester, culminating in a debate on a topical subject in Earth and planetary science.

Petrology and Volcanology

651-4063-00L X-Ray Powder Diffraction

Abstract
In the course the students learn to measure X-ray diffraction patterns of minerals and to evaluate these using different software for qualitative and quantitative mineral composition as well as crystallographic parameters.

Objective
Upon successful completion of this course students are able to:
- describe the principle of X-ray diffraction analysis
- carry out a qualitative and quantitative mineralogical analysis independently,
- critically assess the data,
- communicate the results in a scientific report.

The competencies of system understanding, concept development, and measurement methods are taught and examined.

Content
Fundamental principles of X-ray diffraction
Setup and operation of X-ray diffractometers
Interpretation of powder diffraction data
Qualitative and quantitative phase analysis of crystalline powders (e.g. with Rietveld analysis)

Lecture notes
Selected handouts will be made available in the lecture

Literature

Prerequisites / notice
The course includes a high portion of practical exercises in sample preparation as well as measurement and evaluation of X-ray powder diffraction data.

Own sample will be analysed qualitatively and quantitatively. Knowledge in mineralogy of this system is essential. Software will be provided for future use on own Laptop.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

651-4233-00L Composition and Evolution of the Earth and Planets

Abstract
In this Masters-level course, we address the formation and evolution of the rocky planets with a particular focus on the chemical and isotopic make-up of the Earth and its mantle. This is achieved through analysis of its partial melting products in different tectonic settings and through time.

Objective
Students will gain an insight into cutting-edge research in planetary science and the geochemical evolution of Earth's mantle. The objective is to be able to synthesise scientific studies whose conclusions differ, and, eventually, to form a coherent opinion by debating and scrutinising the available data. This will be achieved by weekly lectures and exercises throughout the semester, culminating in a debate on a topical subject in Earth and planetary science.

651-4037-00L Mineral Resources I

Abstract
Principles of hydrothermal ore formation, using base metal deposits (Cu, Pb, Zn) in sedimentary basins to explain the interplay of geological, chemical and physical factors from global scale to sample scale. Introduction to orthomagmatic ore formation (mostly Cr, Ni, PGE). Introduction to supergene residual deposits (Ni, Al)

Objective
Understanding the fundamental processes of hydrothermal, magmatic and supergene ore formation, recognising and interpreting mineralised rocks in geological context

Content
(a) Principles of hydrothermal ore formation: base metal deposits in sedimentary basins. Practical classification of sample suites by genetic ore deposit types
Mineral solubility and ore deposition, principles & thermodynamic prediction using activity diagrams. Driving forces and structural focussing of hydrothermal fluid flow

(b) Introduction to orthomagmatic ore formation. Chromite, Ni-Cu sulphides and PGE in layered mafic intrusions. Distribution coefficients between silicate and sulphide melts. Carbonatites and pegmatite deposits.

(c) Introduction to supergene residual deposits with emphasis on Ni laterites and bauxites

Lecture notes
Notes handed out during lectures

Literature
Extensive literature list distributed in course

Prerequisites / notice
2 contact hours per lecture / week including lectures, exercises and practical study of samples, and small literature-based student presentations. Supplementary contact for sample practicals and exercises as required. Credits and mark based on participation in course (exercises, 50%) and 1h30 written exam in the last lecture of the semester (50%).

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1063 of 2416
<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td></td>
<td>Concepts and Theories</td>
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<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Techniques and Technologies</td>
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<td>Cooperation and Teamwork</td>
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<td>Analytical Competencies</td>
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<td>Media and Digital Technologies</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
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<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Self-direction and Self-management</td>
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<td>Negotiation</td>
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### Mineral Resources: Courses of Choice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4069-00L</td>
<td>Fluid and Melt Inclusions: Theory and Practice</td>
<td>W</td>
<td>3</td>
<td>3P</td>
<td>T. Driesner, G. Spiekermann, L. Tavazzani</td>
</tr>
</tbody>
</table>

**Abstract**
Block course involving lectures, exercises and practical application of inclusion petrography, microthermometry, Raman and LA-ICPMS microanalysis

**Objective**
Practical ability to carry out a meaningful fluid or melt inclusion study in the fields of geochemistry, petrology or resource geology, involving problem definition, research planning, quantitative measurements using a combination of techniques, critical interpretation and correct documentation of results.

**Lecture notes**
Handouts with extensive list of primary literature available

**Literature**
Goldstein and Reynolds (1994): CD available for in-house use

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4221-00L</td>
<td>Numerical Modelling of Ore Forming Hydrothermal Processes</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>T. Driesner</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to computer tools for the simulation of hydrothermal fluid flow and hydrothermal reactions. The computer programs are handed out to the students and can be run on normal laptop PCs (Windows operating system; MAC or Linux users will have to install a virtual machine or team up with a colleague with a Window computer). No programming knowledge is necessary.

**Objective**
Learn how to use the simulation programs HYDROTHERM and Geochemist's Workbench to explore how hydrothermal or deposition works.

**Content**
Introduction to computer tools for the simulation of hydrothermal processes; HYDROTHERM for fluid flow simulations, Geochemist's Workbench for thermodynamic modeling. While learning the respective computer programs is an essential part of the course, the emphasis will be on using these tools to learn how the physics and chemistry of hydrothermal system actually work.

**Lecture notes**
Computer programs and course material will be distributed during the course.

**Literature**

**Autumn Semester 2022**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4034-00L</td>
<td>Resource Economics and Mineral Exploration</td>
<td>W</td>
<td>3</td>
<td>3P</td>
<td>C. Chelle-Michou</td>
</tr>
</tbody>
</table>

**Abstract**
Global mineral economics and the strategies of mineral exploration -- including geological, geochemical and geophysical methods, but also non-geological factors such as organisational, political and environmental aspects. Changing external lecturers.

**Objective**
Practical understanding of the procedure of exploring a mineral prospect, based on geological analysis, exploration by drilling, resource calculation of tonnage and grade as a basis for economic evaluation for reporting to investors.

**Content**
This block course will comprise 4 half-day lectures and a series of practical exercises from selection of a mineral property to discovery of mineral resources and their valuation. Teams are formed as Limited Partnership companies that have to select and bid for a mineral property offered during an auction. Each company has the same nominal budget. The highest bidder purchases the selected property, others need to purchase the remaining properties during an auction. Justification for selecting the property is justified in a report. The companies must interpret the geology of their mineral property to prepare a diamond drill program to discover and, eventually, delineate the mineral resources. This drill program is presented in a report prior to drilling. Drilling in the tri-dimensional matrix of the property is simulated using the software FOREUR, until budget lapse. The companies must select drill intervals for chemical analysis to document the extent and composition of the discovered mineralization. Portions of the mineral rights can be traded for capital between the companies. An estimate of the tonnage and grade of the discovered resource is prepared using geometric methods and GIS software (ex. ArcGIS). The ground value of the resource is estimated by a computation of the Net Smelter Return at current metal prices. The results of the exploration program are presented in a comprehensive report.

**Lecture notes**
Handouts for background information and a computer simulation program for the case-study exercise will be provided. Participants must bring a Windows-based laptop computer.

**Prerequisites / notice**
Prerequisites: Knowledge of mineral deposit-type characteristics is useful (orogenic gold, Cu-Zn VMS, Ni-Cu-PGE); at least "Integrierte Erdsysteme", "Ore Deposit 1", or adequate knowledge of mineral deposits acquired by preparatory reading. Basic knowledge of ArcGIS software is important to produce maps and sections required in reports. Training exercises and tutorials will be provided in advance to prepare for the course. Taught biennially in collaboration with University of Geneva.

This course is co-organised by ETH Zurich (Prof. C. Chelle-Michou) and University of Geneva (Prof. R. Moritz)
Geochemistry

Geochemistry: Compulsory Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>651-4049-00L</td>
<td>Conceptual and Quantitative Methods in Geochemistry</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>G. De Souza, T. Keller, B. J. Peters</td>
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<td></td>
<td>Prerequisite: Successful completion of the BSc-course “Geochemistry” (651-3400-00L).</td>
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<td><strong>Abstract</strong></td>
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<td>This course will introduce some of the main quantitative methods available for the quantitative treatment of geochemical data, as well as the main modelling tools. Emphasis will both be on conceptual understanding of these methods as well as on their practical application, using key software packages to analyse real geochemical data.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Development of a basic knowledge and understanding of the main tools available for the quantitative analysis of geochemical data.</td>
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<td><strong>Content</strong></td>
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<td>The following approaches will be discussed in detail: major and trace element modelling of magmas, with application to igneous systems; methods and statistics for calculation of isochrons and model ages; reservoir dynamics and one-dimensional modelling of ocean chemistry; modelling speciation in aqueous (hydrothermal, fresh water sea water) fluids.</td>
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<td>We will discuss how these methods are applied in a range of Earth Science fields, from cosmochemistry, through mantle and crustal geochemistry, volcanology and igneous petrology, to chemical oceanography.</td>
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<td>A special emphasis will be put on dealing with geochemical problems through modeling. Where relevant, software packages will be introduced and applied to real geochemical data.</td>
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<td>Slides of lectures will be available.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Pre-requisite: Geochemie I and II</td>
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Planetary Geochemistry

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<tbody>
<tr>
<td>651-4227-00L</td>
<td>Planetary Geochemistry</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>M. Schönächter, H. Busemann, M. Ek</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Formation and evolution of the solar system and its planets from a geochemical perspective</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>To understand the formation and evolution of the solar system and its planets from a geochemical perspective</td>
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<td><strong>Content</strong></td>
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<td>The Sun and solid objects in the solar system (planets, comets, asteroids, meteorites, interplanetary dust) are discussed from a geochemical perspective. What does their present-day composition tell us about the origin, formation and evolution of the solar system? The lectures introduce the basics of the terrestrial and giant planets, comets and asteroids, gained from modern space missions and the study of extraterrestrial materials. The chemical and isotopic composition of meteorites, being the most primitive material available for study, is a further major topic.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Slides and additional materials are available electronically</td>
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Geochemistry: Courses of Choice

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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4233-00L</td>
<td>Composition and Evolution of the Earth and Planets</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. A. Sossi</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>In this Masters-level course, we address the formation and evolution of the rocky planets with a particular focus on the chemical and isotopic make-up of the Earth and its mantle. This is achieved through analysis of its partial melting products in different tectonic settings and through time.</td>
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<td>Students will gain an insight into cutting-edge research in planetary science and the geochemical evolution of Earth's mantle. The objective is to be able to synthesise scientific studies whose conclusions differ, and, eventually, to form a coherent opinion by debating and scrutinising the available data. This will be achieved by weekly lectures and exercises throughout the semester, culminating in a debate on a topical subject in Earth and planetary science.</td>
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<tr>
<td>651-4057-00L</td>
<td>Climate History and Palaeoclimatology</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>H. Stoll, I. Hernández Almeida, H. Zhang</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Climate history and paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.</td>
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<td>The student will be able to describe the natural factors lead to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.</td>
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The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What rates and magnitudes of sea level change have accompanied past ice sheet variations? How stable or fragile is the ocean heat conveyor, past and present?

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimate record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### 651-4225-00L Topics in Geochemistry

**Abstract**

In this course we present and discuss advanced topics in geochemistry based on the critical reading of research papers. Themes include hydrothermal geochemistry, isotopes in meteorites, low temperature geochemistry and biogeochemistry.

**Objective**

The goal of the course is discuss topics in advanced geochemistry which were not covered in other general and specialized geochemistry courses. In addition, we aim at training the student's ability to critically evaluate research papers and to summarize the findings concisely in an oral presentation.

**Content**

Themes will vary from year to year and suggestions from students are welcome. Some possible topics are:

- Organic geochemistry
- Isotope geochemistry of organic matter: carbon, hydrogen and nitrogen
- Clumped isotopes
- Mass-independent isotope fractionation
- Mass transfer and isotopes in modern and ancient ocean-floor hydrothermal systems and subduction zone environments
- Noble gas geochemistry: terrestrial and extraterrestrial applications
- Metal isotopes as tracers for global geochemical cycles

**Lecture notes**

None

**Literature**

Will be identified based on the chosen topic.

### 651-4010-00L Planetary Physics and Chemistry

**Abstract**

This course aims to give a physical understanding of the formation, structure, dynamics and evolution of planetary bodies in our solar system and also apply it to ongoing discoveries regarding planets around other stars.

**Objective**

The goal of this course is to enable students to understand current knowledge and uncertainties regarding the formation, structure, dynamics and evolution of planets and moons in our solar system, as well as ongoing discoveries regarding planets around other stars.

Students will practice making quantitative calculations relevant to various aspects of these topics through weekly homeworks.

The main topics covered are: Orbital dynamics and Tides, Solar heating and Energy transport, Planetary atmospheres, Planetary surfaces, Planetary interiors, Asteroids and Meteorites, Comets, Planetary rings, Magnetic fields and Magnetospheres, The Sun and Stars, Planetary formation, Exoplanets and Exobiology

**Lecture notes**

Slides and scripts will be posted on Moodle.

**Literature**

It is recommended but not mandatory to buy one of these books:


### 651-4229-00L Advanced Geochronology

**Abstract**

This lecture gives an overview of methods and applications of geochronology across a wide range of Earth Science disciplines. Several in their field specialized lecturers cover the principles and methods and will give insight into recent applications and research projects.

**Objective**

The purpose of this lecture is to provide a comprehensive overview of:

- a) the different radiometric methods in Geology, the different dating tasks and the constraints put by the complexity of natural systems, including dating by cosmogenic nuclides, b) the various analytical tools available today for radiometric dating, their advantages and disadvantages, c) the use of noble gases in Geochemistry and d) detailed description of case studies, as examples of approach of a number of geological problems and interpretation of the data.

At the end students know the different isotope systems, methods and their application. Understand literature and critical reading and interpretation of published data is possible. For simple geochronological questions they can describe a scientific approach and possible solution. They can plot and interprete data using IsoplotR for different applications.

**Content**

1. Introduction and overview, Data visualization and statistics in IsoplotR, Principles of U-Pb geochronology
2. In situ U-Pb geochronology 1 (LA-ICPMS/SIMS principles, zircon)
3. In situ U-Pb geochronology 2 (calcite, garnet, other minerals)
4. High-precision ID-TIMS U-Pb geochronology (principles and applications)
5. High-precision U-series geochronology (carbonates, silicates)
6. In situ U-series geochronology (zircon, garnet etc.)
7. K-Ar and 40Ar/39Ar geochronology, Principles and Applications
8. Fission Track dating
9. U-Th/He dating
10. Thermochronology applications/lab visit
11. Noble gases - basics, reservoirs, geo/cosmochem. applications: mainly chronology
12. Cosmogenic nuclides (stable and radionuclides) - basics, geo/cosmochem. applications, C14

**Lecture notes**

Script (for part of the lecture), partly power point presentations (in the web)


Literature

http://elementsmagazine.org/get_pdf.php?fn=e9_1.pdf&dr=e9_1

Geochronology and Thermochronology

Author(s): Peter W. Reiners, Richard W. Carlson, Paul R. Renne, Kari M. Cooper, Darryl E. Granger, Noah M. McLean, Blair Schoene
First published: 8 January 2018


Open Choice Modules Mineralogy and Geochemistry

Modules from the Geology Major
Choice from the Geology Restricted Choice Modules
Choice from the Geology Open Choice Modules

Modules from the Engineering Geology Major
Modules from the Engineering Geology Compulsory Modules

Modules from the Geophysics Major
Modules from the Geophysics Compulsory Modules
Modules from the Geophysics Restricted Choice Modules

Restricted Choice Module of Mineralogy and Geochemistry
Choice from Mineralogy and Geochemistry Restricted Choice Modules
Choice from Mineralogy and Geochemistry Open Choice Modules

Electives

Courses can be chosen from the complete offerings of the ETH Zurich and University of Zurich (according to prior agreement with the subject advisor).

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<tr>
<td>651-1615-00L</td>
<td>Colloquium Geophysics</td>
<td>W</td>
<td>1 credit</td>
<td>1K</td>
<td>A. Obermann, A. Zunino</td>
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<tr>
<td>Abstract</td>
<td>This colloquium comprises geophysical research presentations by invited leading scientists from Europe and overseas, advanced ETH Ph.D. students, new and established ETH scientists with specific new work to be shared with the institute. Topics cover the field of geophysics and related disciplines, to be delivered at the level of a well-informed M.Sc. graduate/early Ph.D. student.</td>
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<tr>
<td>Objective</td>
<td>Attendants of this colloquium obtain a broad overview over active and frontier research areas in geophysics as well as opened questions. Invited speakers typically present recent work; Attendents following this colloquium for multiple terms will thus be able to trace new research directions, trends, potentially diminishing research areas, controversies and resolutions thereof, and thus build a solid overview of state and direction of geophysical research. Moreover, the diverse content and delivery style shall help attendants in gaining experience in how to successfully present research results.</td>
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<tr>
<td>651-0048-00L</td>
<td>Electron Microprobe Course 2 - Practice</td>
<td>W Dr</td>
<td>1 credit</td>
<td>2G</td>
<td>J. Allaz</td>
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<tr>
<td>Abstract</td>
<td>Operation of the Electron Probe Microanalyzer (EPMA), Understanding the fundamentals of the Electron Probe Microanalysis. Interpretation of X-ray spectra for elemental analysis.</td>
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<tr>
<td>Objective</td>
<td>Ability to operate the Electron Microprobe with minimal assistance, optimise the analysis setup in order to obtain excellent results, identify possible source of error (troubleshooting) and fix them, data treatment (and interpretation).</td>
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<td>Content</td>
<td>Physical principles of electron optics, interaction of electrons with matter, production of X-rays, interaction of X-rays with matter. Detection of X-rays. Laboratory work in the field of Earth sciences.</td>
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<td>Lecture notes</td>
<td>Script and User Manual will be provided.</td>
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<td>- Reed S.J.B. (1993, second ed.): Electron Microprobe Analysis</td>
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<td>- 4 full days,</td>
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<td>Prerequisites / notice</td>
<td>-&gt; Restricted attendance, max. 8 students (incl. Doctoral students and external participants). Contact J. Allaz.</td>
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<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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327-0703-00L | Electron Microscopy in Material Science | W | 4 credits | 2V+2U | S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze |
| Abstract | A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials. |
| Objective | A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials. |
This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Lecture notes: will be distributed in English.

Literature:
- Emri: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

651-3541-00L Exploration and Environmental Geophysics  
W 4 credits 3V  P. Edme, H. Maurer, A. Shakas

Abstract: Overview and understanding of the most important geophysical methods: Potential field methods (Gravimetrics and Magnetics), Electrical and electromagnetic methods, Refraction and reflection seismics, Georadar. Discussion of survey design, sources and receivers and data processing.

Objective: Overview and understanding of the most important geophysical methods. Proposed solutions to assess and observe problems relevant to exploration and environmental geophysics, ice and lithosphere at different scales. Getting familiar with measuring- and interpretation procedures. Pointing out the possibilities and limitations of geophysical methods.


Lecture notes: Available through Moodle / eDoz.

Literature:

651-4086-00L Experimental Methods in Petrology  
W 3 credits 2P  C. Liesbse, P. A. Sossi

Abstract: This course introduces the most common experimental methods employed in petrology. Such methods can be used to determine thermodynamic data, physical properties and phase equilibria of minerals, magmas and fluids. The course consists of about 1/3 theory combined with 2/3 hands-on lab-work to demonstrate how experiments are performed in practice.

Objective: The principal goal is to gain knowledge on experimental techniques, and on the principle setup to obtain quantitative data on e.g. phase relations, thermodynamic, kinetic and rheological properties of Earth materials. At the end of the course, participants should be able to evaluate experimental data independently, and design appropriate experiments on their own.

Content: Among other aspects 'Experimental methods in petrology' covers the following subjects:

1. Introduction and historical development of experimental petrology.
2. Experimental methods at ambient pressure (1 bar) with practical exercise to determine basic thermodynamic data.
3. Starting and capsule materials; techniques to buffer chemical activities.
4. External and internally heated high-pressure devices.
5. High-pressure solid-media experimental techniques (piston cylinders).
7. Evaluation of petrologic experiments (preparation of run products, analytical and spectroscopic methods of examination and quantification).

The experiments performed during lab-work will be evaluated in the context of a small research project, which is introduced during the course.

Lecture notes: A summary of the material presented in the lectures is distributed weekly.

Literature: There is no comprehensive book available that summarizes the most important aspects of experimental petrology; key publications on individual subjects are referred to during the lectures.

Prerequisites: This course is aimed at MSc and PhD students, who are interested in experimental methods. No foreknowledge on this is required but basic understanding of petrology and chemical thermodynamics is expected.

651-4114-00L Illustrations in Natural History (University of Zürich)  
W 1 credit 1V  University lecturers

Abstract: No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO271

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Objective: We offer the opportunity to develop drawing skills which can be applied for scientific studies and publications. We emphasize the reproduction of natural objects with and without interpretations. Technical and 3D-drawings as well as descriptive geometry are not dealt with in this course.

Content: We offer the opportunity to develop drawing skills which can be applied for scientific studies and publications. We emphasize the reproduction of natural objects with and without interpretations. Technical and 3D-drawings as well as descriptive geometry are not dealt with in this course.

Lecture notes: -
### 651-4273-00L Numerical Modelling in Fortran

**Prerequisites:**
- 651-4273-00L Numerical Modelling in Fortran

**Objective:**
- Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts.

**Content:**
- The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

**Lecture notes:**
- See http://jupiter.ethz.ch/~pjt/FORTRAN/FortranProject.html

### 651-4273-01L Numerical Modelling in Fortran (Project)

**Prerequisite:**
- 651-4273-00L Numerical Modelling in Fortran

**Objective:**
- The project consists of writing a Fortran program to solve a problem agreed upon between the instructor and student; the topic is often closely related to (and helps to advance) the student’s Masters or PhD research. The project is typically started towards the end of the end of the main Fortran class when the student has acquired sufficient programming skills.

**Content:**
- The project consists of writing a Fortran program to solve a problem agreed upon between the instructor and student; the topic is often closely related to (and helps to advance) the student’s Masters or PhD research.

**Lecture notes:**
- See http://jupiter.ethz.ch/~pjt/FORTRAN/FortranProject.html

### 651-1392-00L Palaeontological Colloquium (University of Zurich)

**Abstract:**
- Talks and discussion on current topics in Palaeontology (Palaeobotany, Palaeozoology and Micropalaeontology).

**Objective:**
- Spezielle Vertiefung paläontologischer Kenntnisse.

**Content:**
- Vorträge von Institutsangehörigen und eingeladenen Gästen aus dem In- und Ausland über aktuelle Themen aus dem Gesamtgebiet der Paläontologie (Paläobotanik, Paläozoologie und Mikropaläontologie) mit anschliessender Diskussion.

### 651-4101-00L Physics of Glaciers

**Abstract:**
- Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

**Objective:**
- After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

**Lecture notes:**
- Will be provided on Moodle

**Prerequisites / notice:**
- High-school mathematics and physics knowledge required.

### 651-0254-00L Seminar Geochemistry and Petrology

**Abstract:**
- Seminar series with external and occasional internal speakers addressing current research topics. Changing programs announced via D-ERDW homepage (Veranstaltungskalender)

**Objective:**
- Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

**Content:**
- Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

### 651-1692-00L Seminar in Applied and Environmental Geophysics

**Abstract:**
- Short seminars on a variety of popular topics in Seismology. The seminars present current problems and research activities in the seismological community.

**Content:**
- Short seminars on a variety of popular topics in Seismology. The seminars present current problems and research activities in the seismological community.

**Objective:**
- Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

**Content:**
- Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.

**Objective:**
- Presentations on isotope geochemistry, cosmochemistry, fluid processes, economic geology, petrology, mineralogy and experimental studies. Mostly international speakers provide students, department members and interested guests with insight into current research topics in these fields.

**Content:**
- Wöchentliches Seminar mit Fachvorträgen eingeladener oder interner Wissenschaftler, vornehmlich zu Themen der Geochemie, Isotopengeologie, Hydrothermalgeochemie, Lagerstättenbildung, Petrologie, Mineralogie und experimentelle Studien.
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<th>Course Code</th>
<th>Course Title</th>
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<th>Period</th>
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<tbody>
<tr>
<td>101-0317-00L</td>
<td>Tunnelling I</td>
<td>3</td>
<td>W</td>
<td>G. Anagnostou, A. Nordas, E. Pimentel</td>
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<td><strong>Objective</strong></td>
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<td>Understanding of a broad scope of current problems and state-of-the-art practice in seismology.</td>
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<td><strong>Abstract</strong></td>
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<td>Basic aspects of design and analysis of underground structures. Conventional tunnel construction methods. Auxiliary measures (ground improvement and drainage, forepoling, face reinforcement). Numerical analysis methods.</td>
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<td><strong>Content</strong></td>
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<td>Numerical analysis methods in tunnelling.</td>
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<td>Conventional excavation methods (full face, top heading and bench, side drift method, ...)</td>
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<td>Method-specific Competencies</td>
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<td><strong>651-1091-00L</strong> Colloquium Department Earth Sciences</td>
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<td>E-Dr</td>
<td>T. I. Eglinton, C. Magnabosco</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>Invited speakers from the entire range of Earth Sciences.</td>
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<td>Selected themes in sedimentology, tectonics, paläontology, geophysics, geochemistry, mineralogy, paleoclimate and engineering geology on a regional and global scale.</td>
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<td><strong>651-2613-00L</strong> Human Geography III (Geographies of Difference)</td>
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<td>(Universität Zürich)</td>
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<td>- Understand basic concepts and empirical manifestations of difference in human geography</td>
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<td>- Deepen knowledge on how difference works in one specific topic of human geography</td>
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<td><strong>Skills</strong></td>
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<td>- Learn to independently digest, assess, and present basic academic texts</td>
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<td>- Conduct discussions in English or German (online and offline) - Be able to write a short research paper about a human geography topic</td>
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<td><strong>651-2601-00L</strong> Human Geography I: One Earth - Many Worlds</td>
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<td>(University of Zurich)</td>
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<td><strong>Objective</strong></td>
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<td>To get an overview about basic research questions and principles of Human Geography</td>
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<td>(1) Society and space (2) Society and development (structure and dynamic of population, urbanisation, disparities (3) Society and natural environment (natural resources; food security, sustainability)</td>
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<td>PowerPoint-slides (German)</td>
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<td><strong>651-4088-03L</strong> Physical Geography III (Geomorphology and Glaciology) (University of Zurich)</td>
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<td>Imparting of research questions and basic principles in Human Geography</td>
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<td>Mind the enrolment deadlines at UZH:</td>
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</table>
Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufes. Dabei werden einzelne Wasserspeicher (Schnee-, Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

651-4088-01L Physical Geography I (Fundamentals and Spheres) (University of Zürich) W 5 credits 2V+2U University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO111

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmssl/en/studies/application/deadline.html

Grundlagen zu Wissenschaftskonzepten und globalen Zusammenhängen bezüglich Atmo-, Litho-, Kryo-, Hydro-, Pedo- und Biosphäre.

651-1617-00L Geophysical Fluid Dynamics and Numerical Modelling E- Dr 0 credits 1S P. Tackley, T. Gerya Seminar

651-4931-00L Seminar I: Heat and Mass Transfers in Magmatology W Dr 1 credit 1S O. Bachmann, C. Chelle-Michou

Heat and mass transfers from the mantle to the crust control many aspects of the differentiation of our planet, including (1) primitive melt chemistry, (2) layering of the crust, (3) type of volcanic eruption, (4) formation of mineral deposits. This year, we will focus on processes in crystal mushes (formation, crystallization, remobilization, degassing).

This class will allow the students to learn about the modern methods and ideas on heat and mass transfers in magmatology through classic and recently published papers. Communication of scientific results to the scientific community and the public is critical. In the class, the students will read and analyse scientific papers and discuss them orally to the class. The students will also create a Wikipedia page and reformulate scientific results for the public.

The class will focus mostly on 1) reading literature on topics of interests, 2) oral and written presentations of the papers, 3) exercises illustrating the topic, to allow students to work by themselves on some well-defined problems.

651-1091-02L Geological Colloquium E- Dr 0 credits 2K S. Bernasconi

Invited speakers from the entire range of Earth Sciences. The presentations are held in German. Membership of the Geological Society in Zurich is not required.

651-1091-02L Seminar II: Heat and Mass Transfers in Magmatology W Dr 1 credit 1S O. Bachmann, C. Chelle-Michou

Does not take place this semester.

651-3280-00L Earth Science Excursions W 1 credit 2P I. Stössel

Only for MSc and doctorate students of D-ERDW. Only for excursions that are not part of the BSc excursion program 2.-6. semester.

With the registration for an excursion or a field course students acknowledge having read and understood the General Terms and Conditions for Field Trips and Excursions https://www.ethz.ch/content/dam/ethz/special-interest/erdw/department/unterricht/ausbildung/ausbuchung/AGB_ERDW_Excursionen_en.pdf

Advanced Earth Science Excursions for students with a special interest in Earth Science field studies.

651-2001-00L Semester Research Project (small) W 3 credits 6A Lecturers

Small individual research project supervised by a lecturer of D-ERDW that builds on the skills acquired during the BSc or MSc studies. The project consists of research activity in a selected scientific topic aimed at producing new scientific results and/or data. Students deepen their knowledge in a specific topic. They familiarize with research procedures and scientific methods that are used in current research. They gain experience in writing scientific reports/papers.

The content of the project consists of research activity aimed at producing new scientific results and/or data. It does not reduce to literature work.

The semester research project is determined by student and supervisor. The topic of each project is unique and not related to the BSc or MSc Thesis.

651-4191-00L Radionuclides as Environmental Tracers W 3 credits 2V N. Casacuberta Arola

Does not take place this semester.

Radionuclides stemming from natural and artificial sources are powerful tools that allow gaining a better understanding of a large range of environmental processes. This course will focus on cosmogenic and anthropogenic radionuclides and will provide a general overview about common applications and the use of tracers in the environment, e.g. to understand past climatic changes and ocean currents.

Students learn the basic facts about sources and fate of natural and artificial long-lived radionuclides (e.g. 14C, 26Al, 10Be, 129I, 236U, Pu isotopes, etc.). They gain insights into the different detection techniques, with special focus on accelerator mass spectrometry (AMS). A selection of the numerous applications of the different radionuclides in oceanic, atmospheric and terrestrial processes will be studied.
1. Earth's magnetic field

All required and recommended scientific publications will be provided online during the course.

Radiocarbon Dating

Semester Research Project (large)

J. Hemingway

Sampling of tree ring layers.

This course focuses on the Earth's magnetic field and the magnetization recorded in rocks as a way to study its past. In addition to mineral

In this hands-on block course, students will have the opportunity to perform radiocarbon analysis of wood samples. This will include

Paleomagnetism: Magnetic Domains to Geologic Terranes by R.F. Butler

C. Welte

11A

2G

Gain an understanding of how paleomagnetism can be used to study the Earth

651-4105-00L Palaeomagnetism  W  3 credits  2G

Does not take place this semester.

Block course takes place again in HS 2023

Abstract

This course focuses on the Earth’s magnetic field and the magnetization recorded in rocks as a way to study its past. In addition to mineral magnetism, field and laboratory methods, and data analysis are covered, as well as the wide range of applications of magnetic methods in Earth sciences, e.g. magnetostratigraphy, studies of the early Earth, geodynamics or structural and tectonic studies.

Objective

Gain an understanding of how paleomagnetism can be used to study the Earth

Content

1. Earth’s magnetic field
2. Mineral magnetism
3. Magnetic remanence
4. Paleomagnetic sampling and tests of stability
5. Data analysis and statistics
6. Paleomagnetic poles and paleogeography
7. Laboratory measurements
8. Topics requested by course participants (anisotropy, magnetostratigraphy, magnetotaxis, ...)

Lecture notes

Slides will be provided during the lecture

Literature

Paleomagnetism: Magnetic Domains to Geologic Terranes by R.F. Butler

http://www.geo.arizona.edu/Paleomag/

Essentials of Paleomagnetism by L. Tauxe

https://earthref.org/MagIC/books/Tauxe/Essentials/

651-4906-00L Radiocarbon Dating  W  2 credits  4P

C. Welte, L. Wacker

Number of participants limited to 6.

Please contact the lecturer for details immediately after subscription.

Abstract

Radiocarbon (14C) dating is the most eminent dating tool for carbon containing samples younger than ~50 kyr and a useful tracer of the carbon cycle. Within this lab course, the sample preparation and 14C analysis of wood samples (or upon agreement other samples) will be performed.

Objective

In this hands-on block course, students will have the opportunity to perform radiocarbon analysis of wood samples. This will include understanding the theoretical background of radiocarbon dating and its importance within Earth Sciences and related fields. Participants will gain know-how on the preparation of wood samples for AMS analysis. They will learn about the importance of suitable reference materials when performing AMS analysis. Data evaluation for C-14 measurements will be performed and discussed.

Content

Sampling of tree ring layers.
Preparation of reference materials and samples for AMS measurement, including chemical pre-treatment and graphitisation.
Assisting the AMS measurement.
Data evaluation and interpretation of results.

Prerequisites / notice

This is a block course for D-ERDW or D-USYS master or PhD students.

Recommended (but not a prerequisite 651-4191-00L Radionuclides as Environmental Tracers (in Autumn Semester) OR 651-4901-00L Quaternary Dating Methods (in Autumn Semester)

651-4145-00L Seminar on Precambrian Geobiology and Biogeochemical Cycles  W Dr  1 credit  1S

J. Hemingway, C. Magnabosco

Abstract

The Precambrian Earth experienced several environmental states—all drastically different from today—that are recorded in sedimentological, fossil, and genetic records. We will review “classic” and more recent scientific literature on the evolution of chemical and biological processes to critically evaluate what we do and don’t know about how our planet’s biogeochemistry has changed through time.

Objective

For decades, researchers have attempted to reconstruct Precambrian environmental states and their relative timing using tracers recorded in the sedimentological, fossil, and genetic records. Here, by reading and discussing “classic” and more recently published scientific papers, students will learn about influential discoveries related to Earth history within the fields of geobiology and geochemistry.

In completing the course, students will specifically learn:

* Why Earth’s surface chemical evolution evolved from anoxic to oxic environments
* How life evolved from simple prokaryotic metabolisms to multicellular eukaryotes
* The importance of geological, chemical, and biological feedback mechanisms
* How to discern between biologic innovation and environmental importance
* How to summarize, interpret, and discuss current evidence for what is and isn’t known about Earth’s geochemical and geobiological evolution
* How to assess opposing scientific viewpoints and outstanding questions in the literature

Content

Each lecture period will consist of a presentation and discussion—to be led by 1-2 students (depending on class size)—covering a given paper or set of papers. All students are expected to read the relevant papers before class and come prepared for discussion. Lecture periods will be divided between “review” presentations aimed at introducing the background and fundamentals of each topic and “debate” or “comparison”-style presentations, in which two (sometimes opposing) views of a given topic will be discussed and assessed.

Lecture notes

Where available, presentations and notes will be provided online during the course.

Literature

All required and recommended scientific publications will be provided online during the course.
Small individual research project supervised by a lecturer of D-ERDW that builds on the skills acquired during the BSc or MSc studies. The project consists of research activity in a selected scientific topic aimed at producing new scientific results and/or data.

Objective

Students deepen their knowledge in a specific topic. They familiarize with research procedures and scientific methods that are used in current research. They gain experience in writing scientific reports/papers.

Content

The content of the project consists of research activity aimed at producing new scientific results and/or data. It does not reduce to literature work.

Prerequisites / notice

The semester research project is determined by student and supervisor. The topic of each project is unique and not related to the BSc or MSc Thesis. The project must be approved in advance by the study advisor.

Fracture Mechanics

Does not take place this semester. The course will be offered by Dr. Luca Dal Zilio starting FS 2023.

Abstract

The course provides an introduction to the concepts of fracture mechanics and its application to the Earth's crust. Theoretical concepts, practical applications, and computational methods are covered. The course has a particular focus on solid Earth applications.

Objective

To acquire the theoretical background of fracture mechanics and to be able to apply them to the solution of relevant problems in geosciences.

Content

2. Elastodynamics: Hooke’s law, Navier–Cauchy equations.
5. Additional: dynamic (inertial) effects, fracture and breakdown energy, coupling between elastodynamics and shear heating, computational methods in fracture mechanics

Prerequisites / notice

Lecture notes and relevant reading materials will be provided. Students are encouraged to take their own notes.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ERDW

see Science in Perspective: Language Courses ETH/UZH

Master’s Project Proposal

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4060-00L</td>
<td>MSc Project Proposal</td>
<td>O</td>
<td>10 credits</td>
<td>21A</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract

The main purpose of the Master Project Proposal is to help students organize ideas, material and objectives for their Master Thesis, and to begin development of communication skills.

Objective

The main objectives of the Master Project Proposal are to demonstrate the following abilities:
- to formulate a scientific question
- to present scientific approach to solve the problem
- to interpret, discuss and communicate scientific results in written form
- to gain experience in writing a scientific proposal

Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>651-4062-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Lecturers</td>
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</table>

Abstract

The master programme will be completed by a master thesis on a topic selected from the subject range of the chosen major programme. Students are to prove their skills in working autonomously on a scientific project.

Objective

Students are to prove their skills in working autonomously on a scientific project. They document their work in a scientific report.

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-3070-AAL</td>
<td>Fundamentals of Geology</td>
<td>E-</td>
<td>6 credits</td>
<td>13R</td>
<td>V. Picotti, W. Behr</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students,
Fundamentals of Geochemistry

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Self-study course. This course is only available for those who got it as an additional requirement in their MSc admission.

Objective
The course is intended to let the student learn fundamentals of geochemistry that were found lacking in his/her studies prior to entering the MSc in Earth Sciences at ETH. Contents of the course will be defined based on text books and/or scientific papers.

Textbooks in English:
- C. Liebske
- T. Gerya

Credits: 30R

Analysis I and II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Mathematical tools for the engineer

Objective
Mathematics as a tool to solve engineering problems.

Content
Complex numbers.

Literature
Textbooks in English:

Textbooks in German:
- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

Physics I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

Content

Literature
- Chapters: 1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Chemistry I and II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective
Understanding principles of theoretical and experimental geothermics and fundamentals of mantle and lithosphere rheologies.

Content
Understanding principles of theoretical and experimental geothermics and fundamentals of mantle and lithosphere rheologies.

Lecture notes
Detailed scriptum in digital form and additional learning modules (www.lead.ethz.ch) available on intranet.

Prerequisite
PPT-files of each lecture may be played back for rehearsal on www.lead.ethz.ch.
Abstract
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature
Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
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</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Negotiation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptable and Flexibility</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

406-0603-AAL Stochastics (Probability and Statistics) E- 4 credits 9R M. Kalisch
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435
  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/
Introduction to Engineering Geology

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

651-3525-AAL

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This introductory course starts from a description of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

Objective
Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

Content

Lecture notes
Lecture Material as defined in German PPT slides of the German Course "651-3525-00L Ingenieurgeologie". Moodle Course Materials available.

Literature
For English speakers study chapters 1-3 of Part I of the book "Geological Engineering" (Gonzalez de Vallejo & Ferrer 2011, CRC Press), without groundwater flow, consolidation time, geophysical methods, details of triaxial tests in soils and rocks, details of clay mineralogy.

Prerequisites
Participate on all exercises of "651-3525-00L Ingenieurgeologie", Tuesday 13-14 pm.

Participate in Written Exam together with students of the German Course.

Materials
Lecture notes
Moodle Course Materials available.

Literature
For English speakers study chapters 1-3 of Part I of the book "Geological Engineering" (Gonzalez de Vallejo & Ferrer 2011, CRC Press), without groundwater flow, consolidation time, geophysical methods, details of triaxial tests in soils and rocks, details of clay mineralogy.

Prerequisites
Participate on all exercises of "651-3525-00L Ingenieurgeologie", Tuesday 13-14 pm.

Participate in Written Exam together with students of the German Course.

Material
Lecture notes
Moodle Course Materials available.

Literature
For English speakers study chapters 1-3 of Part I of the book "Geological Engineering" (Gonzalez de Vallejo & Ferrer 2011, CRC Press), without groundwater flow, consolidation time, geophysical methods, details of triaxial tests in soils and rocks, details of clay mineralogy.

Prerequisites
Participate on all exercises of "651-3525-00L Ingenieurgeologie", Tuesday 13-14 pm.

Participate in Written Exam together with students of the German Course.

Earth Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Mathematics Education Master

### Courses Offered

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

Thematische Schwerpunkte:

- Lernen als Verhaltensänderung und als Informationsverarbeitung
- Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information
- Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers
- Lernen durch Instruktion und Erklärungen
- Die Rolle von Emotion und Motivation beim Lernen
- Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:


**Lecture notes**

Folien werden zur Verfügung gestellt.

**Literature**


**Prerequisites / notice**

This lecture is only apt for students who intend to enrol in the programs "Teaching Diploma" or "Teaching Certificate". It is about learning in childhood and adolescence.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0238-01L</td>
<td>Support and Diagnosis of Knowledge Acquisition Processes (EW3)</td>
<td>W</td>
<td>3</td>
<td>3S</td>
<td>C. M. Thurn, S. Dagauti, P. Edelsbrunner</td>
</tr>
</tbody>
</table>

**Abstract**

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**

The main goals are:

1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

---

### Mathematics Education Master - Key for Type

<table>
<thead>
<tr>
<th>W</th>
<th>Eligible for credits</th>
<th>Z</th>
<th>Courses outside the curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### European Credit Transfer and Accumulation System

- **ECTS**
  - European Credit Transfer and Accumulation System
- **Special students and auditors need special permission from the lecturers.**
Science Education Master

EDUCATIONAL SCIENCE (FOR ALL DIRECTIONS)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. The module additionally gains an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

Thematic Schwerpunkte:

Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzentwicklung unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:


**Lecture notes**

Folien werden zur Verfügung gestellt.

**Literature**


**Prerequisites / notice**

This course is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

---

**Support and Diagnosis of Knowledge Acquisition Processes (EW3)**

**Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the "Teaching Diploma".**

**Prerequisites:** successful participation in 851-0240-00L Human Learning (EW1).

**Abstract**

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

**Objective**

The main goals are:

1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

---

**Biological Direction**

**Specialised Courses**

**Introductory Courses**

**Spec. Courses in Respective Subject with Educational Focus**

---

**Specialized Biology Course with an Educational Focus: Evolution**

**Abstract**

Specialist aspects of biology with a focus on evolution are covered from the angle of imparting these to pupils, their historical development, and their significance for the subject, the individual and society.

**Objective**

After successful completion of the module, students should be able

- to retrieve in-depth knowledge of biology with a special focus on evolution and to impart this to others.
- to analyse controversial topics and to give factual explanations for these.
- to conduct more in-depth work on a research topic and to compile a tuition unit based on this topic.
- to prepare tuition units involving complex learning matter at a high specialist level which are suitably tailored to the recipients, and to teach these in a manner conducive to learning.

**Content**

Selected biological topics, with a special focus on evolution, are dealt with under consideration of the special needs of persons involved in teaching. The module comprises lectures, a book club, and a seminar thesis.

**Lecture notes**

Teaching materials are available online on Moodle.

**Literature**

Literature and references are posted online on Moodle.

**Prerequisites / notice**

The Specialized Biology Course with an Educational Focus consists of two modules (6 CP each). In the fall semester, the focus is on evolution. The module of the spring semester deals with biological concepts. Students attending both modules can start with either module.

Performance is assessed during the course of the entire module. Active participation in the course is required. The thesis (including oral presentation) has to be completed.

The Specialized Biology Course with an Educational Focus (6+6 CP) can be acknowledged, in agreement with the advisor of the respective elective major, as one of the two obligatory research projects (each 15 CP). In such a case, additional 3 CP must be obtained in another course.

In case of overtaking of the course, students enrolled in the Teaching Diploma in Biology will have priority.
Subject Didactics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0913-00L</td>
<td>Professional Exercises in Biology</td>
<td>W</td>
<td>2</td>
<td>2U</td>
<td>P. Faller</td>
</tr>
</tbody>
</table>

**Abstract**
Students conduct a series of “classical” biological school experiments and therefore gain practice and experience in this area. Implementation of Subject Didactics I and II with the focus on conducting biological experiments in schools. This includes finding, testing and further developing suitable protocols for different subject areas of school biology. Working out how to didactically embed the experiments in lessons.

**Objective**
Students can perform, off the cuff, 12 school experiments (which they have tested themselves), from the different subject areas, and conduct these correctly in technical terms. They can incorporate these experiments in their tuition in a didactically meaningful manner.

**Content**

**Prerequisites / notice**
Der Teil biologische Experimente findet im Rahmen von 7 Halbtagen statt.

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Subject Didactics Biology I

*Simultaneous enrolment in Introductory Internship Biology*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0971-00L</td>
<td>Subject Didactics Biology I</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>P. Faller</td>
</tr>
</tbody>
</table>

**Abstract**
- Basic conditions for tuition (MAR - recognition of Matura certificates - curricula, standards), selection of topics and reduction of the complexity of topics.
- Application of teaching methods and techniques from educational science in biology classes.
- Planning and preparation of lessons.

**Objective**
- Students can discuss and put into practice in their teaching work the conditions and objectives set out in the regulations governing the school-leaving examination (Matura), the framework curriculum and the conditions and objectives specified by their school.
- They are in a position to select learning objectives and formulate these on the basis of the target level model. They can plan and prepare lessons and can also develop appropriate learning assignments.
- Students can reconstruct specialist contents in didactic terms and develop teaching modules suitable for the different levels from these on the basis of the subject structure and learner requirements.
- They can reduce the complexity of subject-based specialist contents and present them in such a way that they are comprehensible and meaningful for learners.
- They can select appropriate media for their work (e.g. school books) and use these. They can employ appropriate experiments.
- The students can use different forms of examination for monitoring performance.
- Students are in a position to implement and discuss the concepts of biology teaching and learning on the basis of specific topics covered in school biology.

**Content**

**Lecture notes**
Wird laufend in der Vorlesung abgegeben.

**Prerequisites / notice**
Studierende müssen LE zusammen mit dem Einführungspraktikum - LE 551-0968-00L - belegen.

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Teaching Science in Higher Education

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0091-00L</td>
<td>Teaching Science in Higher Education</td>
<td>W</td>
<td>3</td>
<td>1V</td>
<td>G. Schiltz</td>
</tr>
</tbody>
</table>

**Abstract**
This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context.

**Objective**
Students are able to characterize and to discuss the model of outcomes based education. Students are able to transfer the basic concepts of this model (ILO, TLA, assessment, constructive alignment) to science education.

**Literature**

**Fostered competencies**
Subject-specific Competencies: Concepts and Theories; Techniques and Technologies.
Method-specific Competencies: Analytical Competencies, Decision-making, Problem-solving.
Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Self-awareness and Self-reflection, Self-direction and Self-management.

---

Chemical Direction

Specialised Courses

Introductory Courses

Selection of courses will be agreed with the course coordinator.

Spec. Courses in Respective Subject with Educational Focus
Subject Didactics

529-0950-00L  Subject Didactics Chemistry I

Abstract
Implementing findings from research into teaching and learning for chemistry lessons and coverage of subject-specific teaching and learning specialties.

Objective
The students have basic subject didactic knowledge for teaching chemistry at a secondary school.

Literature
- E. Rossa: Chemie-Didaktik, Cornelsen Verlag, 2015
- H.-D. Barke et al: Konkrete Fachdidaktik Chemie, Oldenbourg Verlag, 2002

Prerequisites / notice
FV A (gelesen im Frühjahrsemester) and FV B (gelesen im Herbstsemester) bauen nicht aufeinander. Die Reihenfolge der Belegung ist somit indifferent.

Subject Didactics

402-0091-00L  Teaching Science in Higher Education

Abstract
This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context.

Objective
Students are able to characterize and to discuss the model of outcomes based education.

Literature

(bite das Buch in der Auflage von 2011 vor dem ersten Treffen erwerben!)
Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Self-awareness and Self-reflection
- Self-direction and Self-management

‖ Physical Direction

↑↑ Specialised Courses

↑↑ Introductory Courses

↑↑ Spec. Courses in Respective Subject with Educational Focus

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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Morf</td>
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</tbody>
</table>

Abstract
Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts. How much energy do we need and can it be provided in a way that allows for sustainable existence?

Objective
Why is energy important for life and our society?
How did energy use change over time? Which effects did these changes have on the environment?
What are the physical basics of energy technologies?
When, why and how did technology and science of energy come together?
What are the limits and benefits of all the various energy technologies?
How can different energy technologies be compared?
Can we understand the changes in the current energy systems?
How will the energy systems of the future look like?
How fast can we and should we enforce the current energy transition?
Which could be the overall guidelines for a working energy system of the future?

Content
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature
The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014
Energy and Civilization: A History, V. Smil, 2018

Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

↑↑ Subject Didactics

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<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0910-00L</td>
<td>Physics Didactics I: Special Didactics of Physics Teaching ■ Limited number of participants.</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Mohr</td>
</tr>
</tbody>
</table>

Further information is available from the lecturer via email: mamohr@ethz.ch
Simultaneous enrolment in Introductory Internship Physics course 402-020-00L - is compulsory for Teaching Diploma Physic

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1081 of 2416
Adaptability and Flexibility

Content

Overview of the Earth as a system, with emphasis on plate tectonic theory and the geological rock-cycle. Provides a basic introduction to Earth Sciences, emphasizing different rock-types and the geological rock-cycle, as well as introduction to magmatic, metamorphic and sedimentary rocks. Exercises are conducted in small groups to provide more in depth understanding of concepts and content of the lectures.

Lecture notes

Folienskizzen und weitere Unterlagen werden zur Verfügung gestellt. Wird während der Veranstaltung mitgeteilt.

Literature

Eligible for credits and recommended

Type

Notices

Prerequisites / notice

Die Veranstaltung ist zusammen mit dem Einführungspraktikum zu belegen.

402-0091-00L

Teaching Science in Higher Education

W 3 credits 1V

G. Schiltz

Abstract

This course imparts fundamental didactic concepts that are relevant to teaching science in a Higher Education context.

Objective

Students are able to characterize and to discuss the model of outcomes based education.

Lecture notes


Fostered competencies

Subject-specific Competencies

Concepts and Theories

assessed

Method-specific Competencies

Analytical Competencies

assessed

Social Competencies

Communication

assessed

Personal Competencies

Adaptability and Flexibility

assessed

Natural Sciences

Number

Title

Type

ECTS

Hours

Lecturers

651-3001-00L

Dynamic Earth I

W 6 credits 4V+2U

O. Bachmann, A. Galli, A. Fichtner, M. Schönbachler, S. Willett

Abstract

Provides a basic introduction into Earth Sciences, emphasizing different rock-types and the geological rock-cycle, as well as introduction to geophysics and plate tectonic theory.

Objective

Understanding basic geological and geophysical processes

Content

Overview of the Earth as a system, with emphasis on plate tectonic theory and the geological rock-cycle. Provides a basic introduction to crystals and minerals and different rock-types. Lectures include processes in the Earth's interior, physics of the earth, planetology, introduction to magmatic, metamorphic and sedimentary rocks. Exercises are conducted in small groups to provide more in depth understanding of concepts and content of the lectures.

Lecture notes

werden abgegeben.

Literature


Prerequisites / notice

Exercises and short excursions in small groups (10-15 students) will be lead by student assistants. Specific topics in earth sciences will be discussed using examples and case studies. Hand samples of the major rock types will be described and interpreted. Short excursions in the region of Zurich will permit direct experience with earth science processes (e.g. earth surface processes) and recognition of earth science problems and solutions relevant for modern society (e.g. building materials, water resources). Working in small groups will allow for discussion and examination of actual earth science themes.

Science Education Master - Key for Type

W+

Eligible for credits and recommended

O Compulsory

W

Eligible for credits

Z Courses outside the curriculum

E-

Recommended, not eligible for credits

Dr Suitable for doctorate
### Key for Hours

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<th>Key</th>
<th>Description</th>
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<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**  
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of

T. Braas, E. Stern

Gender Issues In Education and STEM

ECTS
- Understand research methods used in the empirical educational sciences
- Get to know intelligence tests
- Understanding findings relevant for education

Prerequisites / notice
Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

851-0242-07L Human Intelligence

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Number of participants limited to 30.

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Abstract
The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5-10 students) will be discussed.

Objective
- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

851-0242-08L Research Methods in Educational Science

Number of participants limited to 30.

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Abstract
Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

851-0242-11L Gender Issues In Education and STEM

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract
In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

Objective
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

Content
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

851-0229-00L Using Outdoor Education

Enrolment only possible with matriculation in Teaching Diploma Biology and Geography.

Abstract
In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.
Objective
Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

Content
Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
- Dendrochronology: What annual rings tell
- Photosynthesis/Climate change: The tracks in the forest
- Forest Soil: The soil in the focus of the climate

**Subject Didactics in Geography**

*Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>651-4239-00L</td>
<td>Subject Didactics Geography I (University of Zurich)</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: 090GG1</td>
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<td>Limited number of participants. In addition to the course enrollment a registration by email is required to Dr. Stefan Hesske (E-Mail: <a href="mailto:stefan.hesske@ife.uzh.ch">stefan.hesske@ife.uzh.ch</a>).</td>
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<td>Mind the enrolment deadlines at UZH <a href="https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html">https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html</a></td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Fundamentals (theory and practice) of specialist subject teaching for high-school geography lessons.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>A maximum of 12KP additional requirements in Geography may be open before registering for the didactics Geography.</td>
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<td>Please provide the form <a href="https://ethz.ch/content/dam/ethz/main/education/didaktische-ausbildung/Files/Diverses/Form_Auflagen_bis%2012%20KP_%201215.pdf">https://ethz.ch/content/dam/ethz/main/education/didaktische-ausbildung/Files/Diverses/Form_Auflagen_bis%2012%20KP_%201215.pdf</a> as a confirmation.</td>
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<td>651-4124-00L</td>
<td>Examination Subject Didactics</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>S. Hesske, J. Rafflenbeul</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Die Prüfung Fachdidaktik bildet den Abschluss der didaktischen Ausbildung und wird nach erfolgreichem Abschluss aller Ausbildungsbereiche der didaktischen Ausbildung abgelegt.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>Fähigkeit, Geografie-Unterricht mit Bezug zur eigenen Praxis kritisch und unter verschiedenen Blickwinkeln (inhaltlich, methodisch-didaktisch) zu betrachten, Lernarrangements mit Bezug zum heutigen Bildungs- und Schulfachverständnis zu gestalten und kritisch zu hinterfragen sowie deren möglichen erzielten Wirkungen zu diskutieren und zu begründen; Unterrichtssituationen zu reflektieren und zu evaluieren.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Unterlagen aus der fachdidaktischen Ausbildung</td>
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<td><strong>Literature</strong></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Takes place at the end of the studies, prerequisites: successful completion of the program.</td>
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<td>The examination lessons I and II must be enrolled and completed together with the examination didactics.</td>
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<td>The examination didactics is an 15-minutes oral exam that takes place at the same day together with the examination lessons I and II.</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Project Management</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<tr>
<td>651-4120-00L</td>
<td>Subject Didactics Geography IV: Mentored Project</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>S. Hesske, J. Rafflenbeul</td>
</tr>
<tr>
<td></td>
<td>Prerequisites: successful participation in Geography of Subject Didactics Teaching I, II, III</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Mentorierte Arbeit mit Bezug zur fachdidaktischen Ausbildung.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>selbständige, theoriegestützte Auseinandersetzung mit konkreter, praxisbezogener Fragestellung zum Geographieunterricht.</td>
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<tr>
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<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>selbständige, mentorierte Arbeit zu einem Thema aus der Fachdidaktik mit direktem Bezug zur Lehrpraxis im Fach Geografie (z.B. zu eigenen Übungenlektionen und Praktikum oder zur Unterrichtsforschung).</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<tr>
<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td></td>
<td>May be completed together with didactics III at the earliest.</td>
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</tbody>
</table>
Fostered competencies | Subject-specific Competencies | Concepts and Theories | assessed
| Techniques and Technologies | assessed
| Method-specific Competencies | Analytical Competencies | assessed
| Decision-making | assessed
| Media and Digital Technologies | assessed
| Problem-solving | not assessed
| Project Management | not assessed
| Social Competencies | Communication | assessed
| Cooperation and Teamwork | assessed
| Customer Orientation | not assessed
| Leadership and Responsibility | not assessed
| Self-presentation and Social Influence | not assessed
| Sensitivity to Diversity | not assessed
| Negotiation | not assessed
| Personal Competencies | Adaptability and Flexibility | assessed
| Creative Thinking | assessed
| Critical Thinking | assessed
| Integrity and Work Ethics | not assessed
| Self-awareness and Self-reflection | assessed
| Self-direction and Self-management | assessed

651-4118-00L Subject Didactics Geography III (University of Zurich)  
*No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*  
UZH Module Code: 090GG3  
Limited number of participants. In addition to the course enrollment a registration by email is required no later than September 1 for autumn semester, February 1 for spring semester. Further details see UZH module.  
Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html  
Abstract Working with medias in Geography teaching:  
Part 1: ICT in Geography lessons, subject specific use with concrete examples, evaluating. Planning, implementing and reflecting individual applications.  
Part 2: learning with models, outside school learning (museum didactics). Filming and experimenting in Geography teaching with exercises.  
Prerequisites / notice Geography Didactics III may be completed in parallel with Geography Didactics II, but only after successful completion of Geography Didactics I.

Professional Training in Geography  
*Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-2519-01L</td>
<td>Introductory Internship (University of Zürich)</td>
<td>O</td>
<td>1 credit</td>
<td>2P</td>
<td>University lecturers</td>
</tr>
<tr>
<td>651-2519-02L</td>
<td>Practice Lessons for Subject Didactics (University of Zurich)</td>
<td>O</td>
<td>2 credits</td>
<td>4P</td>
<td>University lecturers</td>
</tr>
<tr>
<td>651-2517-00L</td>
<td>Teaching Internship I Geography (University of Zurich)</td>
<td>O</td>
<td>8 credits</td>
<td>17P</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  
Autumn Semester 2022  
Page 1086 of 2416
The Teaching Internship takes place after successful completion of the didactics courses (I, II incl. practice lessons). The teaching internship takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching internship lasts a maximum of 10 weeks.

Prerequisites / notice
Prerequisites: Successful completion of Educational Science and Subject Didactics in Geography (FD I, II, III) as well as Spec. Courses in Resp. Subj. w/ Educ. Focus & Further Subj. Didactics (PV I, II, III) plus completion of the introductory internship.

The Introductory Internship can only be completed together with an accredited internship teacher of ETH Zurich (separate list).

651-2520-01L Examination Lesson I Geography  
To be completed together with Examination Lesson II 651-2520-02.

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective
On the basis of a specified topic, the candidate shows that they are in a position - to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle - to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Content

Prerequisites / notice
Takes place at the end of the studies, prerequisites: successful completion of the program.

651-2520-02L Examination Lesson II Geography  
To be completed together with Examination Lesson I 651-2520-01.

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective
On the basis of a specified topic, the candidate shows that they are in a position - to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle - to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Content
Die Studierenden erfahren das Lektionsthema in der Regel 14 Tage vor dem Prüfungstermin. Von der zuständigen Lehrperson erhalten sie Informationen über den Wissensstand der zu unterrichtenden Klasse und können sie vor dem Prüfungstermin besuchen. Sie erstellen eine Vorbereitung gemäss Anleitung und reichen sie spätestens 2 Tage vor der Prüfung (bis 18 Uhr) den beiden Prüfungsexperten ein.

Prerequisites / notice
Takes place at the end of the studies, prerequisites: successful completion of the program.

651-4137-00L Semester Paper Within the 1st Teaching Internship Geography (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: 090BPPJ

Abstract
In the context of their first teaching practice, students compile a portfolio in which they analyse and document selected aspects of their teaching experience.

Prerequisites / notice
Only for students of the Geography Teaching Diploma.

The semester paper must be completed together with the first teaching internship, the registration is therefore in the same semester.


<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-2517-02L</td>
<td>Teaching Internship II-E Geography (University of Zurich)</td>
<td>O</td>
<td>6 credits</td>
<td>13P</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html
The Teaching Internship takes place after successful completion of the didactics courses (I, II incl. practice lessons). The teaching internship takes in 40 lessons: 25 are taught by the students. The teaching internship lasts a maximum of 10 weeks.

The teaching internship II has to be completed after the teaching internship I at the end of the program in the same semester. Prerequisite is the successful completion of all courses of the teaching diploma program.

The internship can only be completed together with an accredited internship teacher of ETH Zurich (separate list).

**651-4136-00L Learning Locations for Geography and Geography Didactics (University of Zurich)**

*No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*

**UZH Module Code:** GEO992

*Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsss/en/studies/application/deadline.html*

**Abstract**

The goal of the course is the content-based preparation and didactic conception of different "learning locations" in and around Zurich. The results are to be merged into an attractive excursion guide for teachers (sec. I / II).

**Objective**

- Get to know and explore Zurich from different angles (including urban geography, physical geography)
- Content-based development and didactic implementation of "learning locations" with different thematic priorities for school classes (sec. I / II)
- Project management and group work - Reflection of work results and processes

**Prerequisites / notice**

Successful completion of Geography Didactics I (651-4239-00L).

**Compulsory Elective Courses**

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
851-0229-00L | Using Outdoor Education | W | 1 credit | 1S | R. Schumacher, P. Faller

**Abstract**

In this seminar, future teachers will be trained to prepare and conduct excursions to out-of-school learning venues. For this purpose, excursions are offered at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf.

**Objective**

Future teachers will learn to prepare and conduct excursions to out-of-school learning venues.

**Content**

- Excursions at the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) in Birmensdorf:
  - Dendrochronology: What annual rings tell
  - Photosynthesis/Climate change: The tracks in the forest
  - Forest Soil: The soil in the focus of the climate

**860-0023-00L International Environmental Politics**

**Particularly suitable for students of D-ITET, D-USYS**

**Abstract**

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

**Objective**

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

**Content**

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

**Lecture notes / Literature / notice**

Reading materials and slides will be available via Moodle.

**Additional Requirements (ETH-Masterstudents in ERDW and AC)**

**Part 1**

**Compulsory Modules**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
651-2601-00L | Human Geography I: One Earth - Many Worlds | O | 5 credits | 2V+2U | University lecturers
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO112

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
Imparting of research questions and basic principles in Human Geography

Objective
To get an overview about basic research questions and principles of Human Geography

Content
(1) Society and space (2) Society and development (structure and dynamic of population, urbanisation, disparities (3) Society and natural environment (natural resources; food security, sustainability)

Lecture notes
PowerPoint-slides (German)

Literature

651-2613-00L Human Geography III (Geographies of Difference) (Universität Zürich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: GEO232

Recommended prerequisite: Human Geography II (UZH Module Code: GEO122)

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Abstract
This re-search-oriented course enables students to think through and about difference in a geographically (multi-scalar, critical, space-bound) manner, by elaborating on multiple concepts from postcolonial, intersectional and other disciplinary debates, and by applying these to specific topical domains.

Objective
Knowledge
- Understand basic concepts and empirical manifestations of difference in human geography
- Deepen knowledge on how difference works in one specific topic of human geography

Skills
- Learn to independently digest, assess, and present basic academic texts
- Conduct discussions in English or German (online and offline) - Be able to write a short research paper about a human geography topic

Modules of Choice

Number Title Type ECTS Hours Lecturers
651-2603-00L Geography. Matters. (University of Zurich) W 4 credits 2V University lecturers

Abstract
The course demonstrates geography’s interdisciplinary approach to contribute solving urgent challenges ahead of society. Students are encouraged to reflect on the value of interdisciplinary research at discipline level and on their individual interdisciplinary curricula. The course creates awareness of ways that concepts structure our thinking, and how they figure in research and practice.

Part 2

Number Title Type ECTS Hours Lecturers
651-4088-03L Physical Geography III (Geomorphology and Glaciology) (University of Zürich) W 5 credits 1V+1U University lecturers

Abstract
Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufes. Dabei werden einzelne Wasserspeicher (Schnee-, Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.

Part 3

Number Title Type ECTS Hours Lecturers
651-2338-00L Remote Sensing and Geographic Information Science III (University of Zürich) W 5 credits 2V+3U University lecturers

Abstract
Das Modul bietet eine kurze Einführung in einige Komponenten und Prozesse des hydrologischen Kreislaufes. Dabei werden einzelne Wasserspeicher (Schnee-, Boden und Grundwasser) und Flüsse zwischen den Speichern (Verdunstung, Niederschlag und Abfluss) betrachtet. Übungen ergänzen die Vorlesung.
Abstract
Exercises to the course Introduction Remote Sensing.

103-0214-00L Cartography Fundamentals
5 credits 4G L. Hurni

Objective
Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

Content
Definitions "map" and "cartography", map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critics.

Lecture notes
Will be distributed module by module.

Literature

Prerequisites / notice
Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Customer Orientation</td>
<td>assessed</td>
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<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

Geography Teaching Diploma - Key for Type

| O | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |
| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The goal of this seminar-style course is to convey methods how to do research and communicate research results in the geospatial domain. The course further provides an overview of the types of research in the geospatial domain and the research life cycle.

After this course the students should be able to describe the most important established national and international spatial and temporal reference systems; describe the techniques, processes, and institutions needed to establish and maintain reference frames; select appropriate reference systems and frames for specific geospatial modeling/analysis tasks; carry out coordinate transformations, conversions, and time operations on geospatial data, taking into account and quantifying the uncertainties; combine geospatial data originally referring to different reference frames into a single reference frame.

- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool
- Ability to independently develop a transport model supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

The course introduces basic methods of geostatistics and geospatial data analysis. Topics include spatial correlation, auto-correlation and spatial stochastic processes and random fields; time series models and spatio-temporal analysis.

The course supports the students in acquiring an in-depth understanding of sensors, sensor systems and sensor networks for the acquisition of geospatial data. Emphasis is put on the prediction and assurance of data quality based on an understanding of key sensing principles, external influences, and data acquisition processes.

- Knowledge of time, distance, angle, position, attitude, motion, temperature, optical imaging and spectrum
- Knowledge of the variogram; surface interpolation (kernel-based, kriging, parametric surface models); spatially adaptive filtering (bilinear, guided filter); spatial stochastic processes and random fields; time series models and spatio-temporal analysis.

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

This course is an advanced introduction to spatial and temporal reference systems for acquisition, analysis and communication of geospatial data. The course covers definitions, conventions and comprehensive real world examples of coordinate reference systems, time reference systems, their respective practical realization, and operations for changing data between them.

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

This course is aimed at analyzing, designing, improving public transport systems, as part of the overall transport system.
Objective
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders.
The most relevant decision making problems in a planning tactical and operational point of view
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning time-tabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.

Content
Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Fostered competencies
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<tr>
<td>Concepts and Theories</td>
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<td>not assessed</td>
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</tbody>
</table>

Lecture notes
Lecture slides are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-14666563919 (English)

Abstract
The focus of the lecture Site & Project Development is on larger contiguous areas or sites and their urban, open space and infrastructural development. In this course, students work on a semester exercise in which they “develop” a specific large-scale project from practice and evaluate it economically, strategically and in terms of feasibility.
Objective

Students in this course will pursue the following learning objectives:

- Investigate and understand a given concrete project area and identify, evaluate and articulate the current problems and relevant issues within this area.

- Consolidate their knowledge in the essential topics of site & project development and apply this in a well-founded, argued and creative manner to address the task at hand.

- Organize and structure themselves while acquiring responsibilities in their interdisciplinary project teams. The teams consist of three to five fellow students that must develop innovative, viable and resilient concepts for a real project development in a given area. Their considerations should be presented in written form (project report) and in linguistic-visual form (final presentation). At the end of the course, the students critically reflect on their experiences with the group work process together with the course instructors.

- Acquire methodological knowledge in location & market analysis, 3D visualization of a project as well as in the financial assessment of a large-scale real estate project and use this knowledge to justify their considerations and evaluate their proposal.

- Development and strengthening of their individual position as planners (spatial, urban, transport planners, etc.) in relation to the questions formulated in the proposed project within the field of Site & Development as well as within their own discipline.

Content

The lecture is divided into several thematic sections analogous to the essential topics of Site & Project Development. The students are accompanied both in the semester exercise and in the individual lectures by a large number of external guest speakers from the praxis-field, which means that the lecture will not only thematically examine the relevant areas of Site & Project Development, but also will offer the students exclusive, practice-oriented insights. The relevant methodological knowledge for the semester exercise is imparted and, due to the proximity to practice, the students gain exclusive insights into possible professional fields of activity. In this lecture, students apply their already acquired and newly learned skills, especially in interdisciplinary teams, and work on an exciting, motivating and relevant question from the practice.

Major topics covered in the lecture include:
- Urban planning
- Location and market analysis
- Real estate development, financing and valuation
- Project development and decision-making from the perspective of investors
- Open space design and landscape architecture
- Sustainable building and sustainability certification
- Mobility, parking issues, travel models
- Cooperative planning and participation processes, mediation
- Gendered planning in project development
- Inner development & urban quality

Parallel to the lecture series, students work in interdisciplinary teams on a real-life task. In the course of the semester exercise, the lecture materials are deepened and what has been learned is applied. The students visit the project area at the beginning of the semester as part of an excursion. Specific large-scale projects such as the Gaswerkareal Bern, the Sihl-Manegg Areal Zurich (Greencity) or the Areal Alter Pilatusmarkt (Nidfeld) Lucerne will be dealt with. For the possible development of the given site, visions are developed by the students on the basis of a comprehensive location and market analysis and a utilization concept is developed. In the process, the students are accompanied by experts and regularly discuss their ideas and proposed solutions with their supervisors.

Lecture notes

- Handouts of the lectures
- Extracts from relevant scientific articles and theory literature
- Exercise material

Download: https://irl.ethz.ch/de/education/vorlesungen/msc/project_development.html

Literature

References in the lecture notes

Fostered competencies

Subject-specific Competencies

<table>
<thead>
<tr>
<th>Competency</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Methods &amp; Technologies</td>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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Method-specific Competencies

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<thead>
<tr>
<th>Competency</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Communication</td>
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<tr>
<td>Cooperation &amp; Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<td>Leadership &amp; Responsibility</td>
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<td>Self-presentation &amp; Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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Social Competencies

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<tr>
<th>Competency</th>
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<tbody>
<tr>
<td>Adaptability &amp; Flexibility</td>
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<tr>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity &amp; Work Ethics</td>
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<tr>
<td>Self-awareness &amp; Self-reflection</td>
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<tr>
<td>Self-direction &amp; Self-management</td>
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Personal Competencies

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<tr>
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<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
</table>

Abstract

This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project. Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.
Content - 3D cartography - Web mapping - Data processing - Animations and interactions - Map and UI design - Web application development - Programming (JavaScript).

Lecture notes Handouts of the lectures and exercise documents are available on Moodle.

Prerequisites / notice Cartography II or Introduction to Web Cartography Part 1-2 (MOOC) or similar knowledge in mapping with JavaScript.

Fostered competencies

Subject-specific Competencies
- Techniques and Technologies
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies
- Self-direction and Self-management

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

Literature


Autumn Semester 2022
Prerequisites / notice
It is highly recommended that the student has previously taken the following courses:
102-0617-00L: Basics and Principles of Radar Remote Sensing
and
102-0617-01L: Methodologies for Image Processing of Remote Sensing Data

103-0687-00L Cadastral Systems W 2 credits 2G J. Lüthy

Abstract
Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society.

Objective
Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre and spatial data infrastructures. The link between cadastral systems, gender equality, economic prosperity and the contribution to the achievement of the United Nation Sustainable Development Goals (UN SDG) is discussed. The Swiss cadastral system ("Amtliche Vermessung") as well as a number of international systems in developed as well as in developing countries are discussed.

The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.

Content
Origin and purpose of cadastral systems
Importance of documentation of property information
Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)
Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment
Swiss cadastral system
- legal basis
- organisation
- Technical implementation
- Quality and integrity assurance
- profession
- Embedding cadastral data in the national spatial data infrastructure

Digital revolution and access to data
Benchmarking and evaluations
International trends, developments and initiatives to strengthen property rights

Literature
Adlington, G. (2021): Real Estate Registration and Cadastre - Practical Lessons and Experiences

Fostered competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed
Social Competencies
- Cooperation and Teamwork not assessed
- Sensitivity to Diversity not assessed
Personal Competencies
- Critical Thinking not assessed

851-0724-01L Real Estate Property Law W 3 credits 3V S. Stucki, R. Müller-Wyss

Abstract
Particularly suitable for students of D-ARCH, D-BAUG, D-USYS
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

Objective
The legal principles of real estate property law can be correctly interpreted and applied in daily life.

Content
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

Lecture notes
Abgegebene Unterlagen: Skript in digitaler Form

Literature
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationssrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
After attending this course, students will:

- Adaptability and Flexibility
- Communication
- Concepts and Theories
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

### Mixed Reality

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

- 3D graphics and vision, human machine interaction, as well as gaming technology.
- Presenting their results.
- Technologies such as virtual/mixed reality or mobile applications. They will engage in teamwork, application design, programming and presenting their results.

### Interoperability of GIS

- Explain and apply the model-driven approach based on standards
- Describe and use interoperability types
- Describe transfer formats and reformat them by one-to-one processors
- Explain object-oriented modelling (based on graphical and textual representation)
- Describe and use communication technologies and OGC Web services
- UML, EBNF, INTERLIS, ITF, XML, Python, FME, ModelBaker (QGIS), and PostgreSQL
- Apply appropriate software tools

### GIS and Geoinformatics Lab

Independent study project with novel geoinformation technologies. Information on past projects: http://gis-lab.ethz.ch/

### Mixed Reality

The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

### Interoperability of GIS

Content: Transform geodata with the same content between files with a different structure.

- Explain and apply the model-driven approach based on standards
- Describe and use interoperability types
- Describe transfer formats and reformat them by one-to-one processors
- Explain object-oriented modelling (based on graphical and textual representation)
- Describe and use communication technologies and OGC Web services
- UML, EBNF, INTERLIS, ITF, XML, Python, FME, ModelBaker (QGIS), and PostgreSQL
- Apply appropriate software tools

### GIS and Geoinformatics Lab

- Independent study project with novel geoinformation technologies. Information on past projects: http://gis-lab.ethz.ch/
- This lab focuses on presenting spatial, temporal, and open data in tangible ways. Students will learn how to work with novel geoinformation technologies such as virtual/mixed reality or mobile applications. They will engage in teamwork, application design, programming and presenting their results.

### Mixed Reality

- The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:
  - Introduction to Mixed Reality / Augmented Reality / Virtual Reality
  - Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don’ts is provided through highlighting and discussing real life examples and cases.

12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

**Project Works**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>103-0298-10L</td>
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<td>O</td>
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<td>24A</td>
<td>Supervisors</td>
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<tr>
<td>103-0298-11L</td>
<td>Project 2</td>
<td>O</td>
<td>12 credits</td>
<td>24A</td>
<td>Supervisors</td>
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</table>

**Master’s Thesis**

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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>103-0009-10L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Before starting the Master’s thesis, students must have

a. obtained the Bachelor’s degree;
b. fulfilled all specified admission conditions, if any;
c. acquired at least 90 credits in the Master’s programme, including 12 credits in the area of the interdisciplinary project.

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

To work independently and to produce a scientifically structured work.

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.
The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. Handouts for each topic will be provided.

The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging. The task assignments and selected documentation will be provided as PDF.

### 103-0287-00L Cadastral Systems

**Objective**

Learn how to apply photogrammetry, image analysis and machine learning to mapping tasks; hands-on experience in implementing automatic image analysis methods, and in judging their results.

**Content**

Preprocessing of satellite images, atmospheric correction; extraction of features (radiometric indices, texture descriptors, etc.) from raw image intensities; semantic image segmentation (e.g., cloud masking); physical parameter estimation (e.g., vegetation height); practical deployment of geometric and semantic computer vision and image analysis methods for mapping; assessment of prediction results.

**Prerequisites / notice**

basic knowledge of photogrammetry, image processing and machine learning

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### 103-0787-00L Image-based Mapping

**Abstract**

Application of photogrammetry and remote sensing methods for mapping and Earth observation.

**Objective**

Learn how to apply photogrammetry, image analysis and machine learning to mapping tasks; hands-on experience in implementing automatic image analysis methods, and in judging their results.

**Content**

Preprocessing of satellite images, atmospheric correction; extraction of features (radiometric indices, texture descriptors, etc.) from raw image intensities; semantic image segmentation (e.g., cloud masking); physical parameter estimation (e.g., vegetation height); practical deployment of geometric and semantic computer vision and image analysis methods for mapping; assessment of prediction results.

**Prerequisites / notice**

basic knowledge of photogrammetry, image processing and machine learning

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### 103-0617-00L Project Parameter Estimation

**Abstract**

Solving engineering problems with modern methods of parameter estimation for network adjustment in a real-world scenario; choosing adequate mathematical models, implementation and assessment of the solutions.

**Objective**

Learn to solve engineering problems with modern methods of parameter estimation in a real-world scenario.

**Content**

Analysis of given problems, selection of appropriate mathematical models, implementation and testing using Matlab: Kriging; system calibration of a terrestrial laser scanner.

**Lecture notes**

The task assignments and selected documentation will be provided as PDF.

**Prerequisites / notice**

Prerequisite: Statistics and Probability Theory, Geoprocessing and Parameterestimation, Geodetic Reference Systems and Networks

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### 102-0617-00L Basics and Principles of Radar Remote Sensing for Environmental Applications

**Abstract**

The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

**Objective**

The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. At the end of the course the student has the understanding of:

1. SAR basics and principles,
2. SAR polarimetry,
3. SAR interferometry and
4. environmental parameter estimation from multi-parametric SAR data

**Content**

The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:

1. Introduction into SAR basics and principles
2. Introduction into electromagnetic wave theory
3. Introduction into scattering theory and decomposition techniques
4. Introduction into SAR interferometry
5. Introduction into polarimetric SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

**Lecture notes**

Handouts for each topic will be provided

**Literature**

First readings for the course:


Complete literature listing will be provided during the course.

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### 103-0687-00L Cadastral Systems

**Abstract**

Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society.

**Objective**

Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre and spatial data infrastructures. The link between cadastral systems, gender equality, economic prosperity and the contribution to the achievement of the United Nation Sustainable Development Goals (UN SDG) is discussed. The Swiss cadastral system ("Amtliche Vermessung") as well as a number of international systems in developed as well as in developing countries are discussed.

The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.

**Content**

Origin and purpose of cadastral systems

Importance of documentation of property information

Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)

Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment

Swiss cadastral system
- legal basis
- organisation
- Technical implementation
- Quality and integrity assurance
- profession
- Embedding cadastral data in the national spatial data infrastructure

Digital revolution and access to data

Benchmarking and evaluations

International trends, developments and initiatives to strengthen property rights

**Literature**


Adlington, G. (2021): Real Estate Registration and Cadastre - Practical Lessons and Experiences
### 263-5902-00L Computer Vision

**Abstract**
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

**Objective**
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Content**
- Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

### 851-0724-01L Real Estate Property Law

**Abstract**
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

**Objective**
The legal principles of real estate property law can be correctly interpreted and applied in daily life.

**Content**
- Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

**Literature**
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. Based on that, the 2-D imaging concept used in synthetic aperture radar imaging is treated. Then, we expand further on radar and SAR interferometric (InSAR) concepts and processing steps for single interferograms and stacks of interferograms also using persistent scatterer interferometry (PSI) to measure deformation based on time series of interferometric SAR data. Finally, the 3-D radar imaging case (SAR tomography) is put into context with PSI/InSAR time series as an extension of the more classical interferometric approaches thereby closing the circle around the strongly related concepts of SAR imaging and interferometry.

Study notes/handouts for each topic will be provided online. Additional reading material:

https://doi.org/10.1007/10.306-47633-9

It is highly recommended that the student has previously taken the following courses:

102-0617-00L: Basics and Principles of Radar Remote Sensing
102-0617-01L: Methodologies for Image Processing of Remote Sensing Data

### Abstract

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding. This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing, and growing a venture. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

### Content

12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

- 2h lecture - schedule (±):
  - 15': Introduction
  - 60': (Guest) lecture
  - 15': Discussion related to topic (in groups)
  - 10': Plenary discussion
  - 20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.


### Literature

https://doi.org/10.1007/10.306-47633-9

### Prerequisites / notice

Basic probability theory and statistics, linear algebra, basic programming skills.
Content
Overview of GNSS, Very Long Baseline Interferometry (VLBI), Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments and observation equations. Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the atmosphere. Signal propagation in the ionosphere and troposphere for the different observation techniques and the determination of atmospheric parameters. Equations of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation theory and the determination of satellite orbits.

Lecture notes
Script M. Rotheracher & "Space Geodesy"
This course is an advanced introduction to spatial and temporal reference systems for acquisition, analysis and communication of geospatial data. The course covers definitions, conventions and comprehensive real world examples of coordinate reference systems, time reference systems, their respective practical realization, and operations for changing data between them.

After this course the students should be able to:
- describe the most important established national and international spatial and temporal reference systems;
- describe the techniques, processes, and institutions needed to establish and maintain reference frames;
- select appropriate reference systems and frames for specific geospatial modeling/analysis tasks;
- carry out coordinate transformations, conversions, and time operations on geospatial data, taking into account and quantifying the uncertainties;
- combine geospatial data originally referring to different reference frames into a single reference frame.

Technological ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding. This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

Lecture slides and case material

Major in GIS and Cartography

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>103-0227-00L</td>
<td>Application Development in Cartography</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>L. Hurni</td>
</tr>
</tbody>
</table>
Abstract
This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Objective
Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.

Content
- 3D cartography
- Web mapping
- Data processing
- Animations and interactions
- Map and UI design
- Web application development
- Programming (JavaScript).

Lecture notes
Handouts of the lectures and exercise documents are available on Moodle.

Prerequisites / notice
Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

Fostered competencies

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<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Techniques and Technologies</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Media and Digital Technologies</td>
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<td>assessed</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</tbody>
</table>

103-0747-00L Cartography Lab

Abstract
Independent practical work in cartography

Objective
Independent practical work in cartography

Content
Choice of theme upon individual agreement

Prerequisites / notice
Cartography III

Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

103-0687-00L Cadastral Systems

Abstract
Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society.

Objective
Students will get an understanding of the conception, structure and impact of cadastral systems and related concepts such as land administration, land registry, PLR-cadastre and spatial data infrastructures. The link between cadastral systems, gender equality, economic prosperity and the contribution to the achievement of the United Nation Sustainable Development Goals (UN SDG) is discussed. The Swiss cadastral system ("Amtliche Vermessung") as well as a number of international systems in developed as well as in developing countries are discussed. The importance of the data from the property cadastre for the National Spatial Data Infrastructure (NSDI) and digital transformation will be investigated using various examples.

Content
Origin and purpose of cadastral systems
Importance of documentation of property information
Basic concepts of cadastral systems (legal basis, conceptual principles, types of property, real estate types)
Importance of cadastral systems in the context of the UN SDGs and for societal prosperity due to the impact on economy, society and environment
Swiss cadastral system
- legal basis
- organisation
- Technical implementation
- Quality and integrity assurance
- profession
- Embedding cadastral data in the national spatial data infrastructure

Digital revolution and access to data
Benchmarking and evaluations

Literature

103-0258-00L Interoperability of GIS

Abstract
Content: Transform geodata with the same content between files with a different structure.

Topics: System-neutral and model-driven approach with reality selection, conceptual modeling, flexible standard formats, one-to-one processors, semantic transformation.

Methods: Conceptual schema languages (UML and INTERLIS), data formats (ITF, XML), tools (ILI-Checker, Python, UMLT, FME, ModelBaker).

Fostered competencies

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<tr>
<th>Subject-specific Competencies</th>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1103 of 2416
This lecture mainly treats the semantic interoperability of GIS, which describes a system-independent and model-driven approach for transforming geodata with the same content but different structure from one format into another (and vice versa). The list of topics entails the reality selection, conceptual modeling, flexible standard formats, one-to-one processors, and semantic transformation. In addition to introducing important concepts for semantic interoperability in theory, two popular workflows are presented and trained over several weeks, which include the conceptual schema languages UML and INTERLIS, the flexible transfer formats ITF and XML, the ILL-Checker, Python as parser, and UMLT with FME vs. ModelBaker (QGIS) with PostgreSQL for the semantic transformation.

Objective

- Explain and apply the model-driven approach based on standards
- Describe and use interoperability types
- Describe transfer formats and reformat them by one-to-one processors
- Explain object-oriented modelling (based on graphical and textual representation)
- Describe and use communication technologies and OGC Web services
- UML, EBNF, INTERLIS, ITF, XML, Python, FME, ModelBaker (QGIS), and PostgreSQL
- Apply appropriate software tools

Content

This lecture mainly treats the semantic interoperability of GIS, which describes a system-independent and model-driven approach for transforming geodata with the same content but different structure from one format into another (and vice versa). The list of topics entails the reality selection, conceptual modeling, flexible standard formats, one-to-one processors, and semantic transformation. In addition to introducing important concepts for semantic interoperability in theory, two popular workflows are presented and trained over several weeks, which include the conceptual schema languages UML and INTERLIS, the flexible transfer formats ITF and XML, the ILL-Checker, Python as parser, and UMLT with FME vs. ModelBaker (QGIS) with PostgreSQL for the semantic transformation.

Prerequisites / notice

Condition for participation: Successful bachelor course GIS II (old) or Geoinformationstechnologien und --analysen, GTA (new)
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice
The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

103-0337-00L Site and Project Development
W 3 credits 2G A. Gonzalez Martinez, J. Van Wezemael

Abstract
The focus of the lecture Site & Project Development is on larger contiguous areas or sites and their urban, open space and infrastructural development. In this course, students work on a semester exercise in which they "develop" a specific large-scale project from practice and evaluate it economically, strategically and in terms of feasibility.

Objective
Students in this course will pursue the following learning objectives:
- Investigate and understand a given concrete project area and identify, evaluate and articulate the current problems and relevant issues within this area.
- Consolidate their knowledge in the essential topics of site & project development and apply this in a well-founded, argued and creative manner to address the task at hand.
- Organize and structure themselves while acquiring responsibilities in their interdisciplinary project teams. The teams consist of three to five fellow students that must develop innovative, viable and resilient concepts for a real project development in a given area. Their considerations should be presented in written form (project report) and in linguistic-visual form (final presentation). At the end of the course, the students critically reflect on their experiences with the group work process together with the course instructors.
- Acquire methodological knowledge in location & market analysis, 3D visualization of a project as well as in the financial assessment of a large-scale real estate project and use this knowledge to justify their considerations and evaluate their proposal.
- Development and strengthening of their individual position as planners (spatial, urban, transport planners, etc.) in relation to the questions formulated in the proposed project within the field of Site & Development as well as within their own discipline.
The lecture is divided into several thematic sections analogous to the essential topics of Site & Project Development. The students are accompanied both in the semester exercise and in the individual lectures by a large number of external guest speakers from the praxis-field, which means that the lecture will not only thematically examine the relevant areas of Site & Project Development, but also will offer the students exclusive, practice-oriented insights. The relevant methodological knowledge for the semester exercise is imparted and, due to the proximity to practice, the students gain exclusive insights into possible professional fields of activity. In this lecture, students apply their already acquired and newly learned skills, especially in interdisciplinary teams, and work on an exciting, motivating and relevant question from the practice.

Major topics covered in the lecture include:
- Urban planning
- Location and market analysis
- Real estate development, financing and valuation
- Project development and decision-making from the perspective of investors
- Open space design and landscape architecture
- Sustainable building and sustainability certification
- Mobility, parking issues, travel models
- Cooperative planning and participation processes, mediation
- Gendered planning in project development
- Inner development & urban quality

Parallel to the lecture series, students work in interdisciplinary teams on a real-life task. In the course of the semester exercise, the lecture material is deepened and what has been learned is applied. The students visit the project area at the beginning of the semester as part of an excursion. Specific large-scale projects such as the Gaswerkareal Bern, the Sihl-Maneegg Areal Zurich (Greenocity) or the Areal Alter Pilatusmarkt (Nidfeld) Lucerne will be dealt with. For the possible development of the given site, visions are developed by the students on the basis of a comprehensive location and market analysis and a utilization concept is developed. In the process, the students are accompanied by experts and regularly discuss their ideas and proposed solutions with their supervisors.

Lecture notes
- Handouts of the lectures
- Extracts from relevant scientific articles and theory literature
- Exercise material

Download: https://irl.ethz.ch/de/education/vorlesungen/msc/project_development.html

Literature
References in the lecture notes

Prerequisites / notice
none

Fostered competencies

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<th>103-0317-00L Spatial Planning and Development</th>
<th>O 3 credits 2G</th>
<th>D. Kaufmann, A. Kuitenbrouwer</th>
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<td>Only for master students, otherwise a special permission by the lecturer is required.</td>
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Abstract
The course deals with important theoretical, material and methodical foundations for action and decision-making of spatial relevance. This course discusses central tasks and possible solutions for current and future challenges of spatial development in Switzerland and Europe.

Objective
Spatial development deals with the development, formation and arrangement of our environment. In order to be able to mediate between the different demands, interests and projects of multiple actors, a forward-looking, action-oriented and robust planning is necessary. It is committed - in the sense of a sustainable spatial development - to the economical handling of resources, in particular of the non-replicable resource soil.

The lecture introduces necessary basic knowledge and is based on the following main topics:
- Inward development and challenges of spatial transformation
- Planning approaches and The (political) steering of spatial development
- Interplay of formal and informal processes and processes across different scales of spatial development
- Methods of action-oriented planning in situations of insecurity
- Integrated space and infrastructure development
- Different types of participation in spatial development

By taking up the lecture, the students are able to recognize cross-scale, complex tasks of spatial development and transformation and to use their theoretical, methodical and professional knowledge to clarify them.
# Content
- Planning approaches and political organization in Switzerland
- Tasks of spatial relevance
- Key figures and ratios
- Drivers of spatial development
- Steering spatial development I: Policy
- Steering spatial development II: Formal and informal instruments
- Organizing spatial development I: Governance
- Organizing spatial development II: Processes and organization
- Methods in spatial planning I
- Methods in spatial planning II
- Planning in complex situations
- Participation in spatial development
- Present and future core tasks of spatial development

# Lecture notes
Further information and the documents for the lecture can be found on Moodle


# Fostered competencies

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# 103-0417-02L Methodology of Planning Research and Practice

**W** 3 credits  **2G** A. Peric Momcilovic, T. Hug, R. Streit

*Does not take place this semester.*

*Only for master students, otherwise a special permission by the lecturer is required.*

# Abstract
This course deals with scientific and applied methods and the ways of thinking that are useful in planning practice as well as in scientific research. Students are offered interdisciplinary knowledge from planning practice and research, behavioural economics and social sciences. New perspectives on planning are opened up, which can lead to better results in future projects and research.

# Objective
Keeping the general aim of exploring the basic methodologies in spatial planning research and practice, the specific course learning objectives are as follows:
- to address complex real-world spatial problems in adequate ways
- to know relevant theories and maxims that are subject to specific methods of problem solving
- to identify key questions and key concepts in contemporary planning research
- to select appropriate research methods to properly address the research questions

In practical terms, students:
- learn to deal with uncertainties and estimate quantities
- improve their ability to take decisions based on incomplete data and information
- are informed about different (qualitative and quantitative) methods and techniques for spatial research
- learn about different types of research (theoretical, empirical, action-oriented, qualitative, quantitative)
- get skilled for writing simple research essays
- are urged to question their own knowledge and challenge the course of action taken in planning processes

# Autumn Semester 2022
The course is based on the following questions:

How do we deal with complex issues in planning?
- Forms of knowledge, half-knowledge and not knowing
- Occurrence and explanation patterns for irrational behaviour
- Spatial research and planning practice
- Planning maxims
- Mapping complex topics in research questions

How do we generate knowledge about complex issues?
- Methods for scientific data generation
- Applied handling of quantities and probabilities
- Estimating despite uncertainties
- Opportunities of digitisation in planning (Participation, BigData)

How do we react to complex questions in planning?
- Methods of scientific data analysis
- Making decisions despite incomplete information
- Dealing with robustness and fragility

More specifically, the lectures focus on the following topics (NB: Some content units will be presented in English, they are marked with *asterisk below)
- (Half-) knowledge/behaviour/irrationalities
- Initial situation: Solving complex problems
- Forms of knowledge, knowing of not knowing something, not knowing of not knowing something
- Behavioural patterns, occurrence and explanation patterns for irrational behaviour
- Methods for solving complex issues in planning practice
- Spatial research and planning practice - connections, differences, overlaps
- Challenges in the solution of complex tasks: System delimitation, interdisciplinarity, retrospective vs. prospective approach (descriptive vs. action-oriented, *reflected scenario building*)
- Planning maxims
- *Methodology in spatial research
- *Research design
- *Research questions, types of research questions; research questions, hypotheses and theories; justification of research question
- Data generation methods (interviews and questionnaires, ethnography and observation, documents, official statistics)
- Dealing with quantities, estimations, anchor effect
- Importance of scales and key figures in planning
- Estimation methods
- Danger of the anchor effect
- Digitization in planning
- New data sources and sizes
- Opportunities and challenges through digitisation in planning
- Data analysis methods (quantitative and qualitative data; quantitative analysis of survey data; qualitative analysis - content analysis, discourse analysis, case study, comparative research)
- *Role of science in planning - the perspective of both research and practice
- *Research ethics
- Decisions based on incomplete information
- Dealing with complex systems/roughness
- *Research ethics
- Decisions based on incomplete information
- Dealing with complex systems/roughness
- *Role of science in planning - the perspective of both research and practice

Lecture notes
- Learning materials: available online (Moodle) before corresponding lecture.

Literature

Fostered competencies

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Social Competencies
- Communication
- Assessed
- Customer Orientation
- Assessed
- Leadership and Responsibility
- Not assessed
- Self-presentation and Social Influence
- Assessed
- Sensitivity to Diversity
- Assessed
- Negotiation
- Assessed

Personal Competencies
- Adaptability and Flexibility
- Assessed
- Creative Thinking
- Assessed
- Critical Thinking
- Assessed
- Integrity and Work Ethics
- Not assessed
- Self-awareness and Self-reflection
- Assessed
- Self-direction and Self-management
- Not assessed
Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning, timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.

Content

Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport
Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

Lecture notes
Lecture slides are provided.

Literature

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed
Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

101-0417-00L Transport Planning Methods W 6 credits 4G K. W. Axhausen

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Lecture notes
Moodle platform (enrollment needed)

Literature

103-0347-01L Landscape Planning and Environmental Systems (GIS W 3 credits 2U A. Grét-Regamey, C. Brouillet, M. Galleguillos Torres, N. Klein

Abstract
The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective
- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Developing landscape planning measures for practical case studies

Content
- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes
A script and presentation slides for each exercise will be provided on Moodle.

Literature
Will be named in the lecture.

Prerequisites / notice
Basic GIS skills are strongly recommended.

Fostered competencies

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103-0569-00L European Aspects of Spatial Development W 3 credits 2G A. Peric Momcilovic

Abstract
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective
Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making
Learn how to search for literature, how to write a scientific report, how to present scientific results, and how to critically read and review a scientific article.

K. Schindler

Geomatics Seminar

- European spatial policy agenda: introduction and basic directives
- governance models
- planning models: collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

Lecture notes

The documents for the lecture will be provided at the moodle.

Literature

Obligatory literature:

Recommended literature:

Governance models:

Planning models:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

Planning systems in Europe:

Prerequisites / notice

Only for master students, otherwise a special permission by the lecturer is required.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed

Social Competencies
- Decision-making assessed
- Communication assessed
- Cooperation and Teamwork assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Seminar Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0817-00L</td>
<td>Geomatics Seminar †</td>
<td>O</td>
<td>4</td>
<td>2S</td>
</tr>
</tbody>
</table>

Does not take place this semester.

Abstract

Introduction to general scientific working methods and skills in the core fields of geomatics. It includes a literature study, a review of one of the articles, a presentation and a report about the literature study.

Objective

Learn how to search for literature, how to write a scientific report, how to present scientific results, and how to critically read and review a scientific article.

Content

A list of topics for the literature study are made available at the beginning of the semester. A topic can be selected based on a moodle.
### Interdisciplinary Project Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0298-02L</td>
<td>Interdisciplinary Project</td>
<td>O</td>
<td>12</td>
<td>24A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

#### Objective
Students will exercise important aspects when doing research, such as doing a literature search, writing and referencing, and presenting.

#### Prerequisites / notice
Agreement with one of the responsible Professors is necessary.

#### Abstract
Registration via myStudies from mid-July

#### Content
The project work is supervised by a professor. Students can choose from different subjects and tasks.

#### Objective
Working on a concrete interdisciplinary task in Geomatics

---

### Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0009-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>24</td>
<td>51D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

#### Objective
To work independently and to produce a scientifically structured work.

#### Prerequisites / notice
The project can be carried out in German upon mutual agreement between supervisor and student.

#### Abstract
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

#### Content
The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

---

### Electives

The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

### Recommended Electives of Master Degree Programme

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>W</td>
<td>5</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
</tr>
</tbody>
</table>

#### Abstract
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

#### Objective
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

#### Content
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

#### Prerequisites / notice
Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

### Electives ETH Zurich

Course Catalogue of ETH Zurich

### Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

see Science in Perspective: Language Courses ETH/UZH

---

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0132-AAL</td>
<td>Geodetic Metrology Fundamentals</td>
<td>E-</td>
<td>6</td>
<td>13R</td>
<td>A. Wieser</td>
</tr>
</tbody>
</table>

Enrollment ONLY for MSc students with a decree declaring
Getting to know the most important sensors, operation and calculation methods of Geodetic Metrology

Analytical Competencies assessed

Introduction to the most important sensors, operation and calculation methods of Geodetic Metrology

Survey and staking-out methods

Geodetic instruments and sensors

Determination of 3D-coordinates with GNSS, total station and levelling

Calculation methods of geodetic metrology

Lecture notes

Slides and additional material used in the associated regular course Geodätische Messtechnik G2 (in German) are provided in electronic form.

Literature


Prerequisites / notice

The field course is part of this lecture. Practical exercises complete the subjects taught during the semester.

If evidence of equivalent practical experience in surveying cannot be provided by the student, participation in the field course during the respective next available period (i.e. 1 week in the beginning of the summer holidays) is required.

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>E-</th>
<th>R</th>
<th>Faculty / Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0214-AAL</td>
<td>Cartography Fundamentals</td>
<td>5</td>
<td>11</td>
<td>R</td>
<td>L. Hurni</td>
</tr>
<tr>
<td>252-0846-AAL</td>
<td>Computer Science II</td>
<td>4</td>
<td>9</td>
<td>R</td>
<td>M. Fischer, R. Sasse</td>
</tr>
</tbody>
</table>

Lecture notes

Will be distributed module by module.

Content

Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

Objective

Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

Literature


Prerequisites / notice

Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

Lecture notes

Will be distributed module by module.

Content

Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

Objective

Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

Literature


Prerequisites / notice

Further information at http://www.karto.ethz.ch/studium/lehrangebot.html
### Linear Algebra

**Enrolment only for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction to Linear Algebra and Numerical Analysis for Engineers. This reading course is based on chapters from the book "Introduction to Linear Algebra" by Gilbert Strang (SIAM 2009), and "A First Course in Numerical Methods" by U. Ascher and C. Greif (SIAM, 2011).

**Objective**

To acquire basic knowledge of Linear Algebra and some aspects of related numerical methjods and the ability to apply basic algorithms to simple problems.

**Content**

1. Introduction, calculations using MATLAB
2. Linear systems I
3. Linear systems II
4. Scalar- & vectorproduct
5. Basics of matrix algebra
6. Linear maps
7. Orthogonal maps
8. Trace & determinant
9. General vectorspaces
10. Metric & scalarproducts
11. Basis, basistransform & similar matrices
12. Eigenvalues & eigenvectors
13. Spectral theorem & diagonalisation
14. Repetition

**Literature**


**Prerequisites / notice**

Knowledge of elementary calculus

---

### Analysis II

**Enrolment only for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Mathematical tools of an engineer

**Objective**

Mathematics as a tool to solve engineering problems, mathematical formulation of problems in science and engineering. Basic mathematical knowledge of an engineer.

**Content**


**Literature**

Textbooks in English:
- J. Stewart: Multivariable Calculus, Thomson Brooks/Cole
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus
- M. Akveld, R. Sperb, Analysis II, vdf
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

---

### Analysis I and II

**Enrolment only for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Mathematical tools for the engineer

**Objective**

Mathematics as a tool to solve engineering problems. Mathematical formulation of technical and scientific problems. Basic mathematical knowledge for engineers.

**Content**

- Complex numbers.
- Calculus for functions of one variable with applications.

**Literature**

Textbooks in English:

Textbooks in German:
- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

---

### Stochastics (Probability and Statistics)

**Enrolment only for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.
Objective
The objective of this course is to build a solid foundation in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435
  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m1757b/

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Method-specific Competencies

Problem-solving assessed

Personal Competencies

Self-direction and Self-management assessed

406-0062-AAL
Physics I
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts in mechanics.

Content
Book:

Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature
see "Content"

Friedhelm Kuppers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002, 544 S, ca.: Fr. 68.-

406-0063-AAL
Physics II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content
Book:

Chapters:

Literature
see "Content"

Friedhelm Kuppers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Verlag Wiley-VCH, 2003, Fr. 77.-
Ein Skript in englischer Sprache wird semesterbegleitend herausgegeben. Das Skript und die Folien werden auf der Vorlesungshomepage
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential
G. Möller
Die Vorlesung bietet eine Einführung in das Programmieren mit einem Fokus auf systematischem algorithmischem Problemlösen.
9R
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic,
Fundamentals in geoinformation technologies: database principles, including modeling of spatial information, geometric and semantic
Satellite Geodesy
A. Iozzi, R. Sasse
Overview of GPS, VLBI, Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments
Wir behandeln fundamentale Datentypen, Ausdrücke und Anweisungen, (Grenzen der) Computerarithmetik, Kontrollanweisungen,
Funktionen, Felder, zusammengesetzte Strukturen und Zeiger. Im Teil zur Objektorientierung werden Klassen, Vererbung und Polymorphie
behandelt, es werden exemplarisch einfache dynamische Datentypen eingeführt.
Die Konzepte der Vorlesung werden jeweils durch Algorithmen und Anwendungen motiviert und illustriert.
Lecture notes
Ein Skript in englischer Sprache wird semesterbegleitend herausgegeben. Das Skript und die Folien werden auf der Vorlesungshomepage
um Herunterladen bereitgestellt.
Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
103-2233-AAL GIS Basics
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
Fundamentals in geoinformation technologies: database principles, including modeling of spatial information, geometric and semantic
models, topology and metrics; practical training with GIS software.
Objective
Know the fundamentals in geoinformation technologies for the realization, application and operation of geographic information systems in
engineering projects.
Content
Modelling of spatial information
Geometric and semantic models
Topology & metrics
Raster and vector models
Databases
Applications
Labs with GIS software
Literature
103-0187-AAL Satellite Geodesy
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
GPS, VLBI, SLR/LLR and satellite altimetry: Principles, instrumentation and observation equation. Modelling and estimation of station
coordinates and station motion. Ionospheric and tropospheric refraction and estimation of atmospheric parameters. Equation of motion of
the unperturbed and perturbed satellite orbit. Perturbation theory and orbit determination.
Objective
Understanding the major observation techniques in space geodesy as modern methods applied in Earth system monitoring (geometry,
rotation and gravity field of the Earth and the atmosphere), in national surveying and navigation.
Content
Overview of GPS, VLBI, Satellite and Lunar Laser Ranging (SLR/LLR), Satellite Radar Altimetry with the basic principles, the instruments
and observation equations. Modelling of the station motions and the estimation of station coordinates. Basics of wave propagation in the
atmosphere. Signal propagation in the ionosphere and troposphere for the different observation techniques and the determination of
atmospheric parameters. Equation of motion of the unperturbed and perturbed satellite orbit. Osculating and mean orbital elements. General and special perturbation
theory and the determination of satellite orbits.
Literature
Script M. Rothacher “Space Geodesy”
401-0363-AAL Analysis III
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic,
parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier
series, separation of variables, methods of characteristics.
Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential
equations.
Content

Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Literature


Prerequisites / notice

Up-to-date information about this course can be found at: http://www.math.ethz.ch/education/bachelor/lectures/hs2013/other/analysis3_itet

Abstract

The aim of the course is to provide the fundamental knowledge about earth observation sensors, techniques and methods for bio/geophysical environmental parameter estimation.

Objective

The goal is to familiarise students with the principles and tools of machine learning, and to enable them to apply them for practical data analysis.

Content

multivariate probability distributions; comparison of distributions; regression; classification; model selection and cross-validation; clustering and density estimation; mixture models; neural networks

Literature

- Hastie, Tibshirani, Friedman: The Elements of Statistical Learning, Springer 2009
- Duda, Hart, Stork: Pattern Classification, Wiley 2012

Geomatics Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>W+</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Z</td>
<td>Dr</td>
</tr>
<tr>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>G</th>
<th>U</th>
<th>S</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>A</td>
<td>D</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
<td></td>
</tr>
</tbody>
</table>

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## History and Philosophy of Knowledge Master

### Basic Courses

#### Lectures and Exercises

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>862-0050-00L</td>
<td>Theorie and Methodology MAGPW</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>F. Forster, L. Schurrer</td>
</tr>
<tr>
<td></td>
<td><em>Only for MA History and Philosophy of Knowledge.</em></td>
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</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
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<tr>
<td></td>
<td>Introduction to methods, theories and work techniques of the disciplines represented in the study programme.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>The interdisciplinary seminar is aimed exclusively at students of the master's program &quot;History and Philosophy of Knowledge&quot;. It is designed to give students an insight into the subjects represented in the degree program and their specific requirements, procedures, questions and working techniques.</td>
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<tr>
<td></td>
<td><strong>Prerequisites / notice</strong></td>
<td></td>
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<tr>
<td></td>
<td>Dates: Thursday, 10-12</td>
<td></td>
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</tr>
<tr>
<td>851-0197-00L</td>
<td>Medieval and Early Modern Science and Philosophy</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>to be announced</td>
</tr>
<tr>
<td></td>
<td><em>Does not take place this semester.</em></td>
<td></td>
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</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>The course analyses the evolution of the relation between science and philosophy during the Middle Age and the Early Modern Period.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
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<tr>
<td></td>
<td>The course aims are:</td>
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<tr>
<td></td>
<td>- to introduce students to the philosophical dimension of science;</td>
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<td>- to develop a critical understanding of scientific notions;</td>
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<td>- to acquire skills in order to read and comment on scientific texts written in the past ages.</td>
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<td><strong>Content</strong></td>
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<td>The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.</td>
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<tr>
<td>853-0725-00L</td>
<td>History Part One: Europe (The Cradle of Modernity, Britain, 1789-1914)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>H. Fischer-Tiné</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series asks whether one single model of modernization prevailed on the 'Old Continent' or whether we need to differentiate regionally. A special focus lies on the Swiss experience.</td>
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<td><strong>Objective</strong></td>
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<td>At the end of this lecture course, students can:</td>
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<td>(a) highlight the most important changes in the &quot;long nineteenth century&quot; in Europe;</td>
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<td>(b) explain their long-term effects; and (c) relate these changes to global developments today.</td>
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<td><strong>Content</strong></td>
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<td>The thematic foci include:</td>
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<td>Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Power Point Slides and references will be made available in digital form during the course of the semester.</td>
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<td><strong>Literature</strong></td>
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<td>Mandatory and further reading will be listed on the course plan that is made available as from the first session.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>This lecture series does not build upon specific previous knowledge by the students.</td>
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<tr>
<td>851-0020-00L</td>
<td>Gender and Science</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>N. El Kassar, C. L. Blaser</td>
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<td><strong>Abstract</strong></td>
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<td>This lecture series offers an introduction to the relationship between gender and science, with a focus on the specific intersections with the sciences taught at ETH.</td>
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<td><strong>Objective</strong></td>
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<td>This lecture series is designed to acquaint students from all levels and departments with the various ways in which gender perspectives matter for specific scientific disciplines, as well as for science in general. Students will learn to recognize and analyse the specific ways in which scientific theories and methods are gendered. They will be able to discuss and reflect how these topics are connected to their own scientific disciplines.</td>
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<td><strong>Content</strong></td>
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<td>There is agreement across academic disciplines today that gender influences and structures the production of knowledge and that scientific knowledge production in turn shapes gender notions. Even within &quot;hard&quot; sciences such as mathematics, physics, engineering, etc., gender is a significant factor in determining what counts as &quot;objective&quot; knowledge, who can know it, what kind of knowledge is produced, or how this knowledge is acquired and justified. Feminist research aims to reveal how dominant conceptions of science and knowledge practices disadvantage women*, and other subordinate groups, with the goal of reforming these practices. An important part of feminist critique is to show that such efforts substantially improve the overall quality of research. The semester will start with two introductory lectures acquainting students with research questions in the field of Gender and Science by summarizing its key concepts and methods. It will then continue as a series of weekly guest lectures by scholars from different scientific disciplines that provide accessible insights into the intersection between gender studies and the guest lecturer's research field. Students will thereby be encouraged to learn from concrete examples rather than abstract theory. The goal is for students to understand how to apply concepts and methods of gender studies to their particular disciplines. Intermediate discussions with the students will provide a forum for critically reflecting the content of the lectures and the connections to their own academic fields and practices. All lectures by the guest speakers will also be open to the broader ETH public, while the introductory and discussion sessions are only for registered course participants.</td>
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<td>851-0084-00L</td>
<td>Sound Studies and Literature – A New Paradigm?</td>
<td>W</td>
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<td>2V</td>
<td>A. Alon</td>
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<td><strong>Abstract</strong></td>
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<td>The lecture presents the methodological diversity of sound studies insofar as they are related to the study of literature and undertakes to critically assess exemplary works. It offers an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.</td>
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Is literature silent? The paper pages of the book or the screen of the tablet that we look at while reading might suggest so. Nevertheless, when reading, one cannot help but have the impression that literature contains sound. Doesn’t it allow us to identify authors by their “voice,” for example, or guide our reading through repetitions and assonances? Does it not seem to reproduce the sonic world?

In other words: How is the relationship between literature and sound to be thought of? In recent years a concept of “sound” has emerged in the realm of the so-called sound studies which thinks of acoustic phenomena in their connection with human perceptions and actions (Morat/Ziemer 2018). Research in the context of the ‘sonic turn’ assumes that literature both generates and stores sound and that our understanding of literature should be closely linked to the conceptualization and writing practice of sound as well as the conditions of its production and reception.

Strongly interdisciplinary, this research thus combines perspectives from the cognitive sciences, with approaches from the technical sciences and cultural studies. At times, it has argued to dispense with the traditional fixation on writing and instead to approach literature also through sound practices and listening techniques. These practices and techniques should not only be object of studies, but, employing “listening as a research method” (Holger Schulze), should be integrated into the research methodology.

The lecture will confront the methodological diversity of sound studies insofar as they are related to the study of literature and will undertake to critically assess them. It will offer an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.

851-0328-00L
No Borders: Galileo, Calvino, Primo Levi
M. Buciantini

Objectives:
1) History of science and fiction in the 17th and 20th centuries
2) Theories of science and the representation of knowledge in literature
3) The role of technology in the creation of new literary forms

Content:
Without borders means without disciplinary boundaries, without manuals and school programs that force certain authors to stay “inside” schemes and simplifications. It means freeing oneself from the obligations that certain university systems impose on their students, with the risk of limiting one's view of the great authors as Galileo, Italo Calvino and Primo Levi. Without borders means without disciplinary boundaries, without manuals and school programs that force certain authors to stay “inside” schemes and simplifications. It means freeing oneself from the obligations that certain university systems impose on their students, with the risk of limiting one's view of the great authors.

This is the case with Galileo, Italo Calvino and Primo Levi. Each of them has been many things at once. The first was a scientist but also a philosopher and expert technologist, a builder of mechanical devices and scientific instruments; the second was a novelist but also an editorial consultant and a refined essayist and literary critic; the third was a chemist, writer and witness to an event that marked the history of the twentieth century. The course will explore, on the one hand, the central nodes of Galilean science and, on the other, its reception in two “hybrid” authors such as Calvino and Levi. Through the reading and commentary of texts and images, we will narrate the relationship between science and literature, starting from the contexts in which these three authors found themselves living and discussing the problems and issues that each of them had to deal with.

851-0184-00L
Pluralist Philosophy of Mathematics
R. Wagner

Objectives:
1) To introduce students to mainstream philosophies of mathematics, allowing them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.
2) The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic.

Content:
This course will follow Michèle Friend's book "pluralism in mathematics". It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.

851-0311-00L
Literature and Knowledge / Science and Fiction
A. Kilcher

Objectives:
1) Introduction to literary theory
2) Theories of science and fiction
3) Introduction to literary scientific knowledge research

Content:
Not only the specific genre of "Science Fiction", but fictitious (literary) texts in general are fundamentally about the forms and functions of knowledge and science. In the lecture, these are developed theoretically and discussed using examples. Contrary to what has long been claimed, more recent theoretical approaches assume that literature is not in conflict with scientific knowledge. Rather, it is part of the social formation, order and negotiation of knowledge. This applies not only to "science fiction" but in general to the "science of "fiction", i.e. to the knowledge of literature. In the fictional form of literature, models of knowledge are generated, also with a critical or utopian intention (as in "science fiction"). Moreover, literature draws attention to the central role of order and representation in the sciences, i.e. to their aesthetic and narrative forms.

851-0176-00L
Progress
M. Hampe

Objectives:
Acquire knowledge of basic concepts of progress and their evaluation options.
Content

The U.S. philosopher Chauncy Wright wrote in 1865 in his critique of the famous 19th century popular philosopher Herbert Spencer: “Progress is a grand idea, – Universal Progress is a still grander idea. It strikes the key note of modern civilization. Moral idealism is the religion of our times. What the religion of God, the One, and the All, the Infinite First cause, were to an earlier civilization, such are Progress and Universal Progress to the modern world, – a reflex of its moral ideas and feelings.” (Chauncy Wright, The Evolutionary Philosophy.... Vol. 1, 2nd Ed. 1879). The lecture will give an introduction into the different concepts of progress and try to evaluate them against the background of the current epistemological situation.

851-0092-00L

Artificial vs Human?

Die Doktorierenden können sich die Leistung dieses Kurses im Bereich «überfachliche Kompetenzen» anrechnen lassen.

Abstract
KI-based machines and artificial agents are playing more and more a crucial role in our social and political life. Do they essentially differ from human intelligence and human actors or are they merely an (advanced) version of us? How should we judge on their role? For answering such questions one has to give an account of essential features of intelligence, reason, and agency.

Objective
Participants should learn to know some philosophical accounts of intelligence, reason, and agency. This knowledge should enable them to evaluate the pro and con of answers to questions of the following kind:
1. Is human deliberation and argumentation essentially algorithmic?
2. Is AI confined to smart solutions of given problems or is AI also able to revise the framing of problems?
3. Could artificial agents like robots be responsible for their behavior?
4. Do my smartphone and I constitute an extended, hybrid mind?
5. How should we deal with AI-based machines in our social and political life?

851-0093-00L

Ethical Issues in the Economy

Doctoral students will receive credit for the achievements of this course in the section "Transferable Skills".

Abstract
Ecological crises and growing social inequalities rise the urgent question: Is the global way we are doing economics reasonable? – Which kind of wealth is illegitimate? Is a policy of de-growth needed for protecting our ecological niche? Will technological devices e.g. AI-driven market designs for public goods be the solution or is a change of attitudes necessary to cope with such problems?

Objective
Participants should learn to know and being enabled to evaluate answers to the following questions:
1. To which extent are economic success and wealth something deserved, and to which extent are they the outcome of lucky circumstances or favorable conditions? And what follows from the answer for the judgment on social inequalities?
2. How much consumption and growth are enough?
3. Which commons should not be privatized?
4. What should entrepreneurs and consumers be responsible for?
5. Does a sharing economy promote a responsible way of doing business?
6. Are technologies for regulating production and allocation of resources as well as regulating consumptions of goods apt to cope with problems of social inequality, of protecting our ecological niche, and do they empower producers, investors and consumers to act responsible?
7. What are the good things and what are the bad things about the global capitalist scheme doing business in the 21st century?
8. Do we need a de-globalization of doing economics?

851-0177-00L

Images of Computing

W 3 credits 2G L. Wingert

Abstract
This seminar will explore different areas of our social and scientific life where computational practices have a critical impact. The goal is to provide a pluralistic conception of computing based on what computing looks like when dealing with topics as diverse as climate, law, art, or war. The lectures are delivered by researchers from ETH and abroad, with different disciplinary backgrounds.

Objective
By the end of the course, students will be able to describe and compare different conceptions and practices of computing from multiple disciplinary perspectives. They will be able to evaluate both the differences and the convergences between those conceptions, and critically assess their relation to current trends in science, technology, and society.

Content
Computing has become omnipresent in all dimensions of scientific and social life. Not only have cultural phenomena increasingly become the object of computational analysis, but computational practices have also proved inseparable from the cultural environment in which they evolve. Therefore, it is urgent to critically address the entanglement of computing practices with the main cultural challenges our epoch is facing. The global and collective nature of such problems requires a comprehensive perspective on computing, where social and cultural aspects occupy a central position. For these reasons, thinking about machines as objects requires an interdisciplinary approach, where art is as necessary as engineering, anthropological insights as important as psychological models, and the critical perspectives of history and philosophy as decisive as the axioms and theories of theoretical computer science. In this new edition of the Turing Centre's "Images..." lecture series, we will explore different areas of our current social and scientific life where computational practices have a critical impact in order to reflect on the multiple images of computing resulting from them. Instead of asking what computing is in general, the seminar intends to focus on what computing looks like when dealing, for instance, with a climate model, a text of law, a work of art, a mathematical proof, or a weapon of war. The goal is to achieve a pluralistic conception of computing where its scientific, technical, and cultural aspects remain indissociable. The lectures will be delivered by researchers from ETH and abroad with different disciplinary backgrounds. As part of the Turing Centre, this seminar intends to sow the seed of a suitable and long-term environment for exchanging ideas between multiple fields in the natural sciences and the humanities.

851-0101-31L

The Rise of an Asian Giant: Introduction to the History of Modern India (c. 1600-2000)

W 3 credits 2V H. Fischer-Tiné

Abstract
The lecture offers a survey of the historical trajectories taken by the countries of the Indian subcontinent from the 17th century to the turn of the 21st century. The thematic foci include, but are not limited, to an examination of the question whether or not there was a pre-European South Asian modernity.

Objective
Through this course students are acquainted with the history of one of the most important world regions. The objective is not only to introduce participants to a richly diverse civilization, they are also encouraged to look at interrelations and make comparisons with the West. Through this approach their knowledge of European history is contextualised in a global framework while simultaneously their intercultural sensitivity is being trained.

851-0157-28L

Life and Death

Particularly suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS

W 3 credits 2V M. Nagler

Abstract
This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Objective
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0298-00L

The Modern Literary and Artistic Avantgarde in its European Dimension

W 3 credits 2V S. S. Leuenberger
Avant-garde movements are characterized by progressive notions on art, social and political issues as well as by radical criticism on the current circumstances. This is why the specific characteristics of the historic avant-garde of the early 20th century will be a central theme of this lecture: they cannot be separated from the experience of modernity, of the catastrophic course of the First World War, and of the concept of new models of society whose political implementation is a major goal after the end of the war.

The lecture is part of the ‘Science in Perspective’ course programme aimed at enabling the students to deal with avant-garde texts and artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter Bürger’s assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-criticism".

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic perspective: literary texts and manifest by Heym, van Hoddis, Werfel, Lasker-Schüler, Toller, Marinetti, Ball, Tzara, Hueslenbeck, Hausmann, Apollinaire, Breton, Goll, and others will be read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist Avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of technological innovations, second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and, following the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking resilience to totalitarian ideologies.

### Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0426-00L</td>
<td>Paul Feyerabend's Anarchistic Theory of Knowledge</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>M. Hagner, M. Hampern</td>
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<tr>
<td>851-0011-00L</td>
<td>The Body in Global History</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>E. Valdameri</td>
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Waiting list will be deleted 30.09.2022.

### Literature

The specific texts selected for discussion will vary, but examples include:

- Leopold (1949) A Sand County Almanach
- Carson (1962) Silent Spring
- Jared Diamond (2005) Collapse

Discussions might also encompass films or other forms of media and communication about nature.

### Objective

Paul Feyerabend characterized his magnum opus “Against method” as an ‘anarchistic theory of knowledge’ . In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

### Content

Paul K. Feyerabend characterized his magnum opus “Against method” as an ‘anarchistic theory of knowledge’. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

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### Abstract

The modernist Avant-Garde movements are characterized by a radical rhetoric of apocalypse and rebirth, the genesis of another world and a new mankind. The extension of the “intrinsic logic of the aesthetic form into the social fabric” (H. Ehrlicher), and likewise the intensive examination of the latest technical advancements, new forms of media and their combination, unites them.

This course will provide students with opportunities to read, discuss, evaluate and interpret key texts that have shaped the environmental sciences and management both during the course and beyond.

The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is written, with some additional biographical information about the author). He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session.

Presentation of the text requires the students to prepare by, for example:

- identifying the key points made within the text
- identifying issues of particular personal interest and resonance considering the impact of the text at the time of publication, and its importance now evaluating the text from the perspective of our current societal and environmental position

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic perspective: literary texts and manifest by Heym, van Hoddis, Werfel, Lasker-Schüler, Toller, Marinetti, Ball, Tzara, Hueslenbeck, Hausmann, Apollinaire, Breton, Goll, and others will be read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist Avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of technological innovations, second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and, following the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking resilience to totalitarian ideologies.

### Objective

Avant-garde movements are characterized by progressive notions on art, social and political issues as well as by radical criticism on the current circumstances. This is why the specific characteristics of the historic avant-garde of the early 20th century will be a central theme of this lecture: they cannot be separated from the experience of modernity, of the catastrophic course of the First World War, and of the concept of new models of society whose political implementation is a major goal after the end of the war.

This lecture is part of the ‘Science in Perspective’ course programme aimed at enabling the students to deal with avant-garde texts and artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter Bürger’s assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-criticism".

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This lecture is part of the ‘Science in Perspective’ course programme aimed at enabling the students to deal with avant-garde texts and artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter Bürger’s assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-criticism".

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic perspective: literary texts and manifest by Heym, van Hoddis, Werfel, Lasker-Schüler, Toller, Marinetti, Ball, Tzara, Hueslenbeck, Hausmann, Apollinaire, Breton, Goll, and others will be read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist Avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of technological innovations, second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and, following the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking resilience to totalitarian ideologies.
Students learn the history of the body from mid-eighteenth century onwards through examples taken from the multidisciplinary scholarship on the body with a special, albeit not exclusive, focus on colonial and postcolonial contexts. More specifically, students are sensitized to the historical and cultural variabilities of the human body that challenge scientific understandings of it as an unchanging biological entity. Adopting a humanities perspective on topics like anatomy and surgery, the treatment of the insane, sexuality, physical culture, eugenics, and body productivity, the course looks at shifting attitudes to body health and fitness today, as well as by socioeconomic conditions of modernity. It considers how bodies have historically concerned governments who have classified different (sections of) populations as ‘fit’ or ‘unfit’ to be members of a certain community.

The ‘long durée’ approach of the course allows to consider the continuities and changes in terms of scientific epistemologies and practices regarding the body. In doing so, debated contemporary issues such as assisted reproductive technologies and wearable systems of surveillance of the worker fatigue in the workplace are discussed.

The course is structured thematically, adopts a multidisciplinary approach, and uses academic texts as well as concrete examples. It intends to a) enable STEM students to develop new perspectives on their core subjects by bringing them in dialogue with the themes dealt with; b) familiarise students in general with major topics in the field of the recent scholarship on the body and make them mindful of the multiple ways in which understanding the body and its relationship with culture and power can help think critically of the present we live in.

**851-0040-00L Can it Be Permissible to Kill a Few in Order to Save Many?**

**Abstract**
First, the relevant literature on moral justifications in trolley cases will be discussed (Foot, Thomson, Kamm, Otsuka, Kagan). Second, neuropsychological research on trolley cases (Greene, Haidt, Berkner, Kamm) and third, applications of such moral reasoning in cases potentially arising in autonomous robots (Rahwan, Nyholm and Smids, Wolkstein) will be considered.

**Objective**
Students will gain an overview of the current ethical debates surrounding the legitimacy of homicide-rescue-cases in specific types of situations. They will be enabled to interpret complex texts, identify the arguments, to reflect critically and to put it up for discussion.

**Content**
Killing innocents is generally thought to be morally impermissible – or so it seems from an intuitive point of view. However, there are situations where people can only be saved if less others are killed, for example in some traffic cases, in some cases in natural disasters, medical emergencies, terrorist attacks or humanitarian interventions. In some of these situations our intuitions stand clear and disapproving; it is not permissible to kill, even in order to save many lives, for example, to take the vehicle of one patient in order to save many more other patients. In other situations, the intuitions are less clear or even revert for most of us, like in the famous trolley-bystander case, in which a bystander can divert an out-of-control trolley heading towards five to a track where one person is trapped. How are these moral intuitions to be justified, if they are? In this seminar the relevant literature on moral justifications in such trolley cases will be reviewed as well as on methodological problems pertaining to the role of intuitions in moral justifications. Neuropsychological research on such cases as well as critique of the methods and normative presuppositions used in that research will be debated. Finally, attempts to apply such moral reasoning on allegedly analogous cases arising in autonomous robots will be discussed.

**851-0042-00L Democracy (Theory) and Challenges Posed by the Digital Transformation**

**Abstract**
First, an overview of different theories of democracy will be given in order to make explicit their normatively distinguished features. Second, using examples of the social application of digital technologies, controversies about their impact and normative evaluation are discussed. Third, these dissent are related to the models of democracy elaborated in the first part and analyzed.

**Objective**
Students will gain an overview of different theories of democracy and the associated different types of challenges to democracy posed by the digital transformation of society. They will be enabled to interpret complex texts, to identify the argumentation, to reflect critically and to put it up for discussion.

**Content**
Researchers agree that the digital transformation of society is a challenge to democracy. What is disputed is how exactly it challenges or even endangers it. One reason for the disagreement is certainly due to different descriptions and assessments of the precise social effects and risks of various digital technologies. A second reason has to do with the diversity of theories of democracy. In democratic theory, a distinction is usually made between liberal, republican, pluralist-participatory, and deliberative models of democracy (and often many more). Depending on which model is used (and how exactly it is determined), political participation, elections, accountability of politicians, the role of central legal-political institutions (such as the constitution), political culture, and the quality of discourse in the political public sphere are conceived and evaluated differently.

In a first step, this seminar will provide an overview of different theories of democracy, with the aim of making explicit the normative features of important elements of democracy (such as political participation). In a second step, examples of the social application of digital technologies are used to discuss both divergent descriptions of their impact and controversies about normative evaluations in the research literature. In a third step, these dissent are related to the models of democracy elaborated in the first part and analyzed.

**851-0078-00L Ignorance and Error in the Sciences**

**Abstract**
Ignorance and error are usually unpopular in the sciences and scientific practices, but we know that we cannot get rid of them. In this seminar we will analyze and discuss the different roles of ignorance and error in sciences from a philosophical perspective.

**Objective**
– The students apply philosophical conceptions of ignorance and error to sciences and their own studies.
– The students reflect ignorance and error in their own scientific practice.
– The students discuss controversial positions in an interdisciplinary context.

**851-0086-00L War between Humans, or War against Nature? Biographical, Social, Political and Scientific Aspects**

**Abstract**
In this course, we will discuss texts from the field of philosophy of war (Clausswitz, Hobbes) and compare them to texts about human war against nature (James, Latour), e.g. climate change, pandemics such as Covid-19 or HIV. Important questions are: Is the concept of war only applicable to humans? Is there a difference between politics and nature? Is there a science of war? How is war experienced?

**Objective**
Students learn about the different types of argumentative texts and their historical context. They learn to understand the descriptive and critical value of texts in regard to the topic of war.

**851-0101-77L Science and the State**

**Abstract**
This course will reflect on historical and contemporary relations between science and the state. Through various case studies, we will inquire how these two institutions shaped each other. The case studies will cover various scientific disciplines.

**Objective**
To understand how science helped form the state apparatus, and how politics helped shape science; evaluate the image of science as a free thinking vs. servant of the state; analyze the role of science in generating political authority and political reasoning; analyze how political ideas are expressed in science.

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Social Competencies: Communication
- Personal Competencies: Critical Thinking

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Data: 01.11.2022 12:41
Autumn Semester 2022
Page 1122 of 2416
### 851-0101-90L Aesthetics: On the History and Theory of Beauty

**Abstract**
The meaning of the "beautiful" seems hard to define. Yet intersubjective and objective criteria of the beautiful nevertheless exist. The foundation of aesthetics as a "science" of the beautiful based on sensuous experience temporarily suspended this tension. Since modernity, the question of the beautiful has been ever more open. We shall approach this question theoretically and historically.

**Objective**
The meaning of the "beautiful" seems hard to define. At first glance, it rather constitutes a merely subjective sensation. Yet, on the other hand, intersubjective, collective and cultural ideas, or even objective criteria of the beautiful exist. Since antiquity, this irresolvable tension has characterized the discourse on the beautiful in the realms of art and philosophy. With the foundation of "aesthetics" in the 18th century, however, this debate was significantly altered. This new "science" aimed at a scientific investigation of the beautiful by situating sensuous impression above logic. While art had hitherto understood as a learnable technique, it now appears as a sensuous and therefore subjective realization. The rejection of this optimism marks the turn to modernity that defined itself through a notion of art transcending the beautiful. Ever since, the question as to the meaning of the beautiful has been continuously open for debate. In the course of this seminar, we shall approach this question from a historical as well as theoretical perspective.

### 851-0435-00L Science and Neoliberalism: From the Critique of Planning to Competition and Think Tanks (1930–2000)

**Abstract**
From its beginning, the history of neoliberal thought has been linked to debates about the status of knowledge in society. In the seminar, students learn to understand fundamental debates in science in their political and economic contexts; moreover, we explore to what extent neoliberal thinkers actually shaped specific forms of science policy and research funding in the 20th century.

**Objective**
The seminar promotes an understanding of seminal texts in the early philosophy of science (M. Polanyi, J.D. Bernal, etc.) in the context of ideological struggles in the 1930s and 1940s and of the debates about knowledge, science, and society at that time. Moreover, it provides insights into the political and economic foundations of funding policies for education, science, and research that were developed since the 1970s.

**Content**
Neoliberalism is considered one of the most influential economic currents since the last decades of the 20th century. However, neoliberalism not only has a much longer history, going back to the ideological struggles of the 1930s. Since then, it has also been closely linked to debates about the status of knowledge and science in society. Theorists of science, such as Michael Polanyi, were part of neoliberal discussion circles; economists, such as Friedrich Hayek, developed decentered forms of knowledge as part of market processes. In this way, they criticized the contemporary demand for economic planning and the idea of science serving social needs. Competition and the market were subsequently regarded as the most important driving forces for scientific and economic innovation.

**Literature**

### 851-0436-00L Popularizing Science. Nonfiction Books Between Academy and Public

**Abstract**
Science needs to be popularized in order to have an impact on society. Conversely, what is thought, read, and communicated outside the universities has an effect on research. The seminar deals with the history of popular knowledge focusing on the non-fiction book.

**Objective**
The seminar focuses on the reading and discussion of original and secondary texts on the history of the relationship between knowledge, the book market and the public. Students learn to critically engage with sources as well as research literature from the fields of literary, scientific, and book and media history. The amount of reading will be limited; what is important above all is the seminar discussion. Cooperation with actors in the literary business (authors, agents, editors, publishers) is planned. The students shall learn to prepare interviews and to write short texts in the form of non-fiction.

**Content**
Knowledge cannot be separated from the forms in which it is expressed. An important genre of (popular) knowledge representation is non-fiction. In this seminar we will look at how non-fiction books are actually made and how they are published and read at different times. Using examples from the history of non-fiction (Yvul N. Harari to Rachel Carson, C.W. Ceram to Charles Darwin/Ernst Haeckel), the seminar will shed light on the changing relationship between knowledge, the market, and the book format. What topics/subjects are en vogue contemporarily? How do non-fiction books produce and narrate knowledge? How do they establish authority, how do they establish evidence? What notions of (scholarly) authorship, what notions of reading are associated with non-fiction books? What political, media, and cultural contexts play a role in this?

### 851-0516-05L Mobility and the Border: Migration and Control between Mexico and the USA, 19th–21st Century

**Abstract**
The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

**Objective**
A) The students know relevant approaches of the studies of migration, they are able to assess the analytical capacities of these approaches and they know how to apply them in concrete events and processes.
B) The students have acquired knowledge about important aspects of the history of migration between Mexico and the United States.
C) The students are able to identify relevant relations between scientific and technological change on the one hand and developments of migration and its control on the other.

**Content**
The land border between Mexico and the United States, where the 'global North' and the 'global South' meet in the most prominent form worldwide, provides an exemplary case to study how borders generate spaces of agency, constitute human communities and create identities – not only by separating people but also by connecting them. The course is not limited to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

### 862-0115-00L Morality of War and Peace

**Abstract**
Can a war ever be morally justified? The focus of the seminar is the controversial debate in contemporary philosophical thinking about the moral problem of war, humanitarian intervention, the "new wars", terrorism and targeted killing.

**Objective**
The learning objective is twofold: the students should get to know the most important traditions of philosophical thinking about the morality of war; and they should learn to interpret philosophical texts, to think through the difficult problems that the texts raise, and to argue for and against the theses that are made explicit in the various approaches.

Each participant is asked to choose a specific violent political conflict or war that interests him/her, be it historical or current. The students are given the opportunity to give a short lecture on the problem of moral justification in their concrete example using the philosophical theories discussed in the course.

### 851-0296-00L Narrating Time

**Abstract**

**Objective**

**Content**

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1123 of 2416
Developing a case-specific approach, coping with relevant literature and enhancing one's competence in the critical evaluation of:

**Term Paper in Theoretical Philosophy (HS 2022)**
- Lecturers: W
- Content: It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is inherently narrative and therefore articulated best in the form of narrations. But is it even possible to narrate time? What kind of translation is that? And, above all, what are the costs of, and the resistances to, such a translation?

**Term Paper in Science of Knowledge (HS 2022)**
- Lecturers: P. Gerard
- Content: It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is inherently narrative and therefore articulated best in the form of narrations. But is it even possible to narrate time? What kind of translation is that? And, above all, what are the costs of, and the resistances to, such a translation?

**Term Paper History of the Modern World (HS 2022)**
- Lecturers: O
- Content: It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is inherently narrative and therefore articulated best in the form of narrations. But is it even possible to narrate time? What kind of translation is that? And, above all, what are the costs of, and the resistances to, such a translation?

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**Semester Report**

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<tr>
<td>862-0006-00L</td>
<td>Semester Report</td>
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**Semester Paper**

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<tr>
<td>862-0008-28L</td>
<td>Term Paper History of Technology (HS 2022)</td>
<td>W</td>
<td>5</td>
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<td>862-0009-27L</td>
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<td>862-0011-26L</td>
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<td>W</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1124 of 2416
Objective
Developing a case-specific approach, coping with relevant literature and an enhancing one's competence in the critical evaluation of historic sources are the learning targets of this course.

**862-0015-08L** Term Paper in History and Philosophie of Mathematical Sciences (HS 2022)  
**Type** W  
**ECTS** 5  
**Hours** 11A  
**Lecturers**

**Abstract** Term paper that allows students to explore a topic of their choice in greater depth, applying the fundamental knowledge they have acquired so far.

**Objective** The development of a research question, the careful handling of the secondary literature and an increased source-critical competence form the learning objective.

## Major Courses

### Essays

In each subject of the master reading lists are handed out. The books on these lists are the subject of the tutorials one has to attend with the teachers that are named in the Leitfaden. In three subjects essays are to be written about works on these lists.

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<th>Number</th>
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<td>W</td>
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<td>21A</td>
<td>Lecturers</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>This essay is the outcome of an individual teaching and learning process during several terms and draws upon representative books and articles in history of technology. It has to consider the state of the art in the field.</td>
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<td><strong>Objective</strong></td>
<td>Writing this essays intents to become acquainted with methods, tools and concepts relevant for the students master thesis.</td>
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<td>862-0023-00L</td>
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<td>Lecturers</td>
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<td>Essay on Readings in History of the Modern World (HS)</td>
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<td>862-0035-00L</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>One-to-one supervisions form the basis for an essay covering the paradigmatic texts studied over several semesters. This essay should also take recent research into account. The instructor will work one-to-one with the student to hone the skills and fundamental topics that are relevant for the Master's thesis.</td>
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## Seminars

In the seminars topics from the introductory courses are taught in more detail. Topics for essays are to be arranged with the teachers of the courses.

## Research Colloquium

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<td>Research Colloquium Philosophy for Master Students and PhD (HS 2022)</td>
<td>W</td>
<td>2</td>
<td>1K</td>
<td>R. Wagner, M. Hampe, N. Mazouz, L. Wingert</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Ph.D. students, post docs, members of staff, and senior colleagues from other philosophy departments will report on their work in progress. Furthermore, promising new philosophical articles and parts of new philosophical books will be studied.</td>
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<td><strong>Objective</strong></td>
<td>Ideas and arguments dealing with systematic problems especially in epistemology, ethics, political philosophy, and the philosophy of mind will be scrutinized and elaborated.</td>
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Information for UZH students:  
Enrolment to this course unit only possible at ETH. No enrolment for the respective module at UZH.  
Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses/special-

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<tr>
<td><strong>Abstract</strong></td>
<td>For PhD and postdoctoral students. Master students are welcome.</td>
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students/special-students-university-of-zurich.html

Abstract
The fortnightly colloquium provides an ideal forum for Master and PhD students as well as postdoctoral researchers to familiarize themselves with current trends in global history. The slots are reserved for presentations by invited external scholars of the highest calibre.

Objective
Participating students will have an opportunity to follow high level debates in global history. By writing short reports and comments on two selected sessions they train the ability to summarize complex arguments and articulate their position in controversial debates.

Prerequisites / notice
Information about dates and program
http://www.gmw.ethz.ch/studium.html

862-0088-11L Research Colloquium Science Studies (HS 2022) ■ W 2 credits 1K M. Hagner

Abstract
This colloquium is devoted to the introduction into the theory and practice of scientific work. The schedule can be found on the institute’s website - http://www.wiss.ethz.ch/en/teaching/

Objective
This colloquium is devoted to the introduction into the theory and practice of scientific work.

Prerequisites / notice
Lectures may be held either in English or German. Students receive 2 credit points for submitting a brief, written commentary on one of the presented topics (approx. 5 pages).

862-0089-11L Advanced Colloquium in Literary Studies (HS 2022) ■ W 2 credits 1K A. Kilcher

Abstract
Colloquium is designed for advanced and graduated students.

Objective
The colloquium addresses advanced and graduate students. First, it offers participants the opportunity to present their own research projects (work in progress); and, second, it provides a most fruitful space to discuss methodological, theoretical and systematic complex issues.

851-0551-20L Colloquium for Master and PhD Students History of Technology (HS 2022) W 2 credits 1K D. Gugerli

Abstract
Colloquium for master and doctoral students preparing a thesis in the history of technology.

Objective
Goals: to identify, discuss, and resolve methodological problems that emerge while elaborating a master or doctoral thesis.

Prerequisites / notice

851-0041-00L Research Colloquium for Practical Philosophy Does not take place this semester. W 2 credits 1K N. Mazouz

Abstract
Current topics of practical philosophy are discussed on the basis of texts and lectures

Objective
Students are introduced to current research in the field of practical philosophy.

Master’s Thesis
The work on the master-thesis is supervised by one of the teachers that are allowed to offer tutorials for it, named in the Leitfaden.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>862-0500-00L Master's Thesis ■ A student is only permitted to commence the Master thesis if</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
<td></td>
</tr>
<tr>
<td>a. the Bachelor degree programme has been completed</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>b. any additional requirements for admission to the degree programme have been fulfilled</td>
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<tr>
<td>c. all credits have been acquired in the categories basic courses and major courses and at least 6 credits have been acquired in the category research colloquium</td>
<td></td>
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</table>

Abstract
The Master’s thesis gives a thorough historical, philological or philosophical analysis of a topic related to the experimental or formal sciences or to technology. It incorporates the relevant research literature on this topic as well as first attempts at original research.

Objective
The master thesis gives a thorough historical, philological or philosophical analysis of a topic related to the experimental or formal sciences or to technology. It incorporates the relevant research literature on this topic as well as first attempts at original research.

History and Philosophy of Knowledge Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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<tbody>
<tr>
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<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
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<th>V</th>
<th>Lecture</th>
<th>P</th>
<th>Practical/laboratory course</th>
</tr>
</thead>
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<tr>
<td>G</td>
<td>Lecture with exercise</td>
<td>A</td>
<td>Independent project</td>
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<td>U</td>
<td>Exercise</td>
<td>D</td>
<td>Diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>Seminar</td>
<td>R</td>
<td>Revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>Colloquium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The course “Didactic Basics for Student Teaching Assistants” enhanced Student Teaching Assistants (Student TAs) to develop knowledge, capability and confidence to effectively plan and teach courses and exercises. Participants got trained to think critically about students’ learning and create learning situations in which students are actively engaged.

In this course, Student Teaching Assistants will...

- reflect on their approach to teaching as well as their attitude towards teaching.
- understand the basics of teaching and learning in the context of their subject.
- consciously design the introduction of their course as well as the introduction of single teaching units.
- apply classroom assessment techniques as formative assessments to measure the current status of their students.
- develop a didactic concept according to the learning objectives.
- conduct interactive sequences as learning activities.
- give and get feedback from peers and self-reflect on their teaching practice.
- feel confident to use methods for active learning scenarios in their classes.

The online course provides a range of relevant topics for developing teaching competences of Student Teaching Assistants:

- Overview about how learning works. Based on these fundamentals of learning, participants reflect on their role as Student TAs to feel comfortable in their new role as a teacher.
- Plan an own lesson by introducing a class and locate it in the larger topic (methods: portal and informative introduction).
- Develop learning activities in order to activate students (active learning methods).
- Giving and also getting feedback. The participants integrate this topic also in their lesson plan.

While working through the online course, Student TAs have the chance to reflect, exchange ideas with peers and plan their own teaching accordingly so that they feel confident in their role.

The course “Coaching Students” enhances Student Teaching Assistants (Student TAs) in their role as student coaches to develop basic knowledge about coaching methodology and the mindset of a coach.

In this course, Student Teaching Assistants will...

- understand the basics of coaching and the role as student coach.
- develop the mindset of a coach and reflect on their attitude towards guiding student learning processes.
- acquire coaching skills and build knowledge of how coaching works.
- design the coaching session and feel confident to use coaching methods.
- give and get feedback from peers and self-reflect on their coaching practice.

The further 4 live sessions will provide a range of relevant topics for developing coaching competencies:

- Overview about coaching: Based on this, participants reflect on their role as student coaches in order to develop the mindset of a coach.
- Introduction into coaching methodology.
- Coaching skills training: active listening, asking questions and giving/getting feedback.
- Develop learning activities in order to activate students (active learning methods).

During the last live session, course participants will be able to apply their knowledge and the coaching skills learned during the course in a role play.

Further, the course also consists of an online part. The online part offers a short theoretical overview of each live session and the possibility to conduct a learning journal.

The course starts with a Kick-off meeting in the first lesson to provide an overview of the role as student coach and the course in general. Participation in the Kick-off (1st live session on Wed., 5 October 2022) is essential, since during this session the groups are formed in which the students will work throughout the semester. The further 4 live sessions will provide a range of relevant topics for developing coaching competencies:

- Overview about coaching: Based on this, participants reflect on their role as student coaches in order to develop the mindset of a coach.
- Introduction into coaching methodology.
- Coaching skills training: active listening, asking questions and giving/getting feedback.

During the last live session, course participants will be able to apply their knowledge and the coaching skills learned during the course in a role play.

Further, the course also consists of an online part. The online part offers a short theoretical overview of each live session and the possibility to conduct a learning journal.

Overview of course topics sorted according to the live sessions on Wednesdays from 4:15pm-6pm (16:15-18h):

- 5 Oct. 2022: Kick-off: Information about the course, role as a student coach.
- 19 Oct. 2022: Active listening.
- 9 Nov. 2022: Role play (practice the skills you have learned during the semester).

Participants who successfully complete the quiz in the course will receive a verification of completion.

This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities.

This course offers a variety of teaching skills which will help Doctoral Teaching Assistants with their teaching tasks.
Objective

In this course Doctoral Teaching Assistants will:

- discuss learning science and teaching techniques with peers.
- design the introduction of their course/lecture/exercise class.
- develop learning activities according to learning objectives.
- practice classroom assessment techniques in order to measure student learning.
- engage in peer feedback in order to improve own teaching.

Content

We will meet for the kick-off meeting online on the 3rd of October 2022 from 1-3 pm. You will get detailed information together with the invitation email in the first week of the semester. The online phase, where you work through 6 modules in the Moodle course page will end by the 11th of November 2022. We will meet on the 16 or 17th of November 22 for the Consolidation workshop. You will find more information on the course page in Moodle.

Prerequisites / notice

This programme is designed for ETH Doctoral Teaching Assistants with current teaching responsibilities (exercises, excursions, supervision of practicals, lectures, etc.) or those who will assume teaching tasks in the semester following the programme. No previous teacher training is required.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>865-0008-00L</td>
<td>Policy Evaluation and Applied Statistics</td>
<td>Z</td>
<td>3</td>
<td>2G</td>
<td>I. Günther, K. Harttgen, K. Schneider</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41

Autumn Semester 2022

Page 1128 of 2416
### Military History I (Without Exercises)

**Objective**
- Distinguish between military history as a subject and historiography as a way of describing events;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Based on the approach regarding revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Exemplify the issues regarding the evolution of the combat (First and Second World War, Vietnam War and Algerian War).

**Content**
The lecture first examines the bases of the science of (military) history. It focuses on how military history developed from war history, on specific similarities and differences between military history and general historiography, the different ways of dealing with history in Switzerland, Germany, France and in the Anglo-Saxon cultural area (different approaches) as well as on institutions which deal with military history such as universities, military academies, national and international commissions and associations etc.

The lecture is structured along the lines of the concept of “Military Revolution” and starts with the formation of modern, European armed forces after the Oranian Army reform in the 17th century. Based on the “Military Revolution” approach, the lecture examines the structural changes regarding the armed forces and the development of warfare from the 18th to the 20th century. Special emphasis will be put on how the battlefield was revolutionized due to the Napoleonic wars, the industrialization in the 19th century, the First World War, the mechanization and totalization during the Second World War and the period of the Cold War.

**Literature**

### Strategic Studies I

**Abstract**
The lecture series treats high-impact strategic theory from antiquity to the present.

**Objective**
The participants know how the understanding of strategy has evolved over time. They understand the interplay of strategy's basic components: ends, ways, means.

The most important classics of strategy and war theory, especially against their specific historical background. Based on the analysis of historical and contemporary examples, they are aware of the mismatch between declaration and implementation of any given strategy. They are capable of analyzing original texts and modern scholarly works in the field of strategic studies.

**Content**
The two-term lecture series treats classic texts of strategic studies from antiquity to the present. Term 1 covers the theories up until roughly 1900, term 2 treats the theories ever since.

Theories are considered classic if they were prominent in their respective times and if they enjoyed a strong reception thereafter, be it in literature, in academic debates or as guidelines for action (doctrine). Each out of some 50 theories is discussed in three steps: historical context, core elements and reception.

**Lecture notes**
Prior to the lectures, the respective slides are provided as well as a primary sources and literature, as preparatory readings (via Moodle).

**Literature**
Peter Paret, Makers of Modern Strategy. From Machiavelli to the Nuclear Age, Princeton 1986.


### Military Sociology I

**Abstract**
Beside of the most important terms of sociology, demographic changes and the related value and structure change will be analysed. The second part focuses on organizational sociology. Thirdly, the course examines to which extent armed forces can be considered as organizations like any other and to which extent they constitute a special case from an organizational and normative point of view.

**Objective**
Recognize and explain current changes (social change) in modern society (individualisation, pluralisation); describe demographic changes in Switzerland; explain the structures of societies; define issues and fields of research in modern military sociology and explain the foundations of organisational sociology; explain the military in terms of organisational sociology and identify specific traits of the military as an organisation.

**Content**
Societal change; organizations as societal phenomena; aims, structures, environments of organizations; specifics of the military as an organization; impacts of technological and societal changes on the armed forces in modern societies.

**Literature**
A reader with a set of texts will be handed out.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-direction and Self-management: not assessed

Techniques and Technologies
- not assessed
- Decision-making: not assessed
- Problem-solving: not assessed
- Project Management: not assessed
- Leadership and Responsibility: not assessed
- Sensitivity to Diversity: assessed

853-0101-02L Defense Economics I  
Z  3 credits  2V  M. M. Keupp

Abstract
In terms of structure and content, the event follows the lecturer's book "Militärökonomie" (Military Economics), which is available in two language versions:

- German language: ISBN 978-3-658-06146-3

Objective
* Recognizing parallels and contrasts between business and military thinking;
* Recognize and analyze planned economic systems;
* Understand the link between institutions, human action and economic results.

Content
The semester program of the course is divided into 14 modules of 90 minutes each, which combine lecture (teaching of analytical techniques) and exercise (application by means of concrete case studies).

The contents correspond to sections 1 to 2.2.5 of the above book. The following will be discussed:

1. fundamental military economic problems including historical introduction to the topic
2. the institutional foundations of a military organisation
3. the modern military as a planned economy system
4. actors and stakeholders in the system

Lecture notes
Lecture slides are given to the participants before the first lecture. In addition, the above mentioned book will be handed over to the participants. Participants of the lecture who are not professional officer candidates are requested to obtain the book from the library or bookstore.

Literature
ISBN 978-3-658-06146-3

ISBN 978-3-658-25287-8

Prerequisites / notice
none.

853-0033-00L Leadership I  
Z  3 credits  2V  M. Holenweger, F. Demont

Abstract
For BA Public Policy and DAS Military Sceinces only.

The lectures "Leadership I" (WS) and "Leadership II" (SS) have been designed as a two-semester lecture series, but may also be followed independently of one another or in reverse order. "Leadership I" covers the following fields: leadership basics, leadership theories and leadership styles, the concept of leadership responsibility and the role of communication in practical leadership.

Objective
The aim of this lecture is to give students an introductory overview of relevant topics regarding leadership research and practice, thus enabling them to gain a deeper understanding of the leadership phenomenon. Students should understand different concepts of leadership in the complex interaction between individuals, groups, organisation, context and situation. They should be informed about the evolution of the understanding of mankind in relation to working processes and its impact on organizations and the understanding of leadership theory in the past 100 years. They should grasp the concept of leadership responsibility (leadership ethics) and be able to derive consequences for leadership in practical situations. They should recognize the fundamental importance of communication in leadership situations and receive input which enables them to communicate adequately in specific situations.

Specialized Continuing Education

Special internal ETH courses offered by LET and the Teaching Specialists.

Number Title Type ECTS Hours Lecturers
999-9999-99L EduApp Course E- 0 credits 1V+1U B. Volk

This course unit is not a genuine ETH course unit. It is used by LET and the Teaching Specialists for EduApp demonstration purposes.

Humanities, Social and Political Sciences (General Courses) - Key for Type

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<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Eligibility</th>
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</thead>
<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1130 of 2416
## Key for Hours

<table>
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<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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**ECTS**
- European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
First Year Core Courses

First Year Examinations Part 1

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>551-0033-00L</td>
<td>Molecular Genetics and Cell Biology</td>
<td>O</td>
<td>5</td>
<td>5G</td>
<td>J. Corn, F. Allain, K. Köhler</td>
</tr>
</tbody>
</table>

Abstract

This course teaches the basic principles of evolution, cell biology, molecular biology, genetics and developmental biology using the example of humans.

Objective

1) Students can explain the importance of evolution for the development of humans and diseases.
2) The students know the cell as the smallest unit of the body. They can explain how the functions of the cell are disturbed in certain diseases and where therapies intervene. They can describe the multiplication of cells in the body and show how errors in this multiplication can lead to diseases.
3) The students know DNA as the basis of life. They can explain how the DNA information is stored and how this information can be reproduced and protected from damage. They can describe how the information is read and translated into proteins. They can explain which mechanisms at the level of DNA, RNA and proteins can cause diseases.
4) Students can explain which technologies can be used to diagnose and treat diseases.
5) Students can explain how people differ genetically and know the molecular basis of these differences. They can explain how these differences can lead to diseases and why some of these differences do not affect diseases.
6) The students know the molecular causes of the most common hereditary diseases and can determine the probability of occurrence and transmission to offspring.
7) Students can explain the biochemical and molecular basis of human reproduction and know the basic principles of human embryonic development. The students can explain which mechanisms can be disturbed by a faulty development.

| 529-1001-03L | General Chemistry (for HST)                 | O    | 6    | 4V+2U | J. Cvengros          |

Abstract

The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.

Objective

The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.

Literature

Weiterführende Literatur:
Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch)

| 252-0852-00L | Foundations of Computer Science            | O    | 4    | 2V+2U | L. E. Fässler, M. Dahinden |

Abstract

Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects.

Objective

The students learn to
1. understand the role of computer science in science,
2. to control computer and automate processes of problem solving by programming,
3. choose and apply appropriate tools from computer science,
4. process and analyze real-world data from their subject of study,
5. handle the complexity of real-world data.

Content

1. The role of computer science in science
2. Introduction to Programming with Python
3. Modeling and simulations
4. Data management with lists and tables
5. Data management with a relational database
6. Introduction to Matrices

Lecture notes

All materials for the lecture are available at www.gdi.ethz.ch

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1132 of 2416
Mathematics I/II is an introduction to one- and multidimensional calculus. Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences.

Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems.

Linear Algebra emphasizing on applications.

Basic reaction thermodynamics and kinetics; reactive intermediates: carbanions, carbenium ions and radicals.


Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences. They can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems.
Content

## Eindimensionale diskrete Entwicklungen ##
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsraten
- Folgen und Grenzwerte

## Funktionen in einer Variablen ##
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

## Differentialrechnung (I) ##
- Veränderungsrate/-geschwindigkeit
- Differentialquotient und Ableitungsfunktion
- Anwendungen der Ableitungsfunktion

## Integralrechnung (I) ##
- Stammfunktionen
- Integrationstechniken

## Gewöhnliche Differentialgleichungen (I) ##
- Qualitative Beschreibung an Beispielen: Beschränkt, Logistisch, Gompertz
- Stationäre Lösungen
- Lineare DGL 1. Ordnung
- Trennung der Variablen

## Lineare Algebra ##
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

Lecture notes

In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:

* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature

**L. Papula**
Mathematik für Ingenieure und Naturwissenschaftler, 2 Bände; Springer Verlag Vieweg.
Via ETHZ-Bibliothek:

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände: Einführung in die Analysis, Einführung in die Lineare Algebra; Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF
auch als [pdf](https://people.math.ethz.ch/~blatter/linalg.pdf)

Prerequisites / notice

## Übungen und Prüfungen ##
+ Die Übungsauflagen (inkl. Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltung.
+ Es wird erwartet, dass Sie mindestens 75 % der wöchentlichen Serien bearbeiten und zur Korrektur eintreffen.
+ Der Prüfungsstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

#### Second and Third Year Core Courses

##### Examination Blocks

##### Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

Basic knowledge of the anatomy and physiology of tissues, of the embryonal and postnatal development, the sensory organs, the neuromuscular system, the cardiovascular system and the respiratory system.

Objective

Basic knowledge of human anatomy and physiology and basics of clinical pathophysiology.
The lecture series provides a short overview of human anatomy and physiology.

Anatomy and Physiology I (fall term):
Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system.

Anatomy and Physiology II (spring term):
digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.

Prerequisites / notice
Requirements: 1st year, scientific part.
Part of the course is read and checked in English.

401-0293-00L Mathematics III

Abstract
Vertiefung der mehrdimensionalen Analysis mit Schwerpunkt in der Anwendung der partiellen Differentialgleichungen, Vertiefung der Linearen Algebra und Einführung in die Systemanalyse und Modellbildung.

Objective
Die Studierenden
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenthalben explizit berechnen: diskret/kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.

Content
- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Die Studierenden
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenthalben explizit berechnen: diskret/kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.

401-0643-13L Statistics II

Abstract
Vertiefung von Statistikmethoden. Nach dem detailierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

Objective

Examination Block B

Number Title Type ECTS Hours Lecturers
402-0083-00L Physics I O 4 credits 3V+1U K. S. Kirch

This course is an introduction to classical physics, with special focus on applications in medicine.
Each of the 6 sessions has its own tutorial and will be handed out to the students. This course will provide insight into various aspects of medical device design such as patient needs assessment, product specification, and warranty; mechanics of a rigid body; fluid mechanics; introduction to electricity.

Prerequisites / notice
Voraussetzung Mathematik I+II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin) / Mathematik-Lehrveranstaltungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)

### Examination Block C

only offered in spring semester.

#### Individual Subjects and Laboratory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0019-00L</td>
<td>Laboratory Course in Medical Technology</td>
<td>O</td>
<td>2</td>
<td>2P</td>
<td>J. G. Snedeker</td>
</tr>
<tr>
<td></td>
<td>Only for BSc HST students. Students from other degree programmes please contact: <a href="mailto:hcoopet@ethz.ch">hcoopet@ethz.ch</a></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>This practical course is designed to give students hands on experience in CAD, FEM, product optimization, mechanical load testing, software development and hardware utilization in robotics.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The course aims at teaching and solidifying following topics: CAD, FEM, Product optimization, Mechanical testing, Software development</td>
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<tr>
<td>Content</td>
<td>The course is aimed at improving the students knowledge on certain topics such as programming in python and biomechanics, but also teaches new skills such as using CAD software, FEM and mechanical testing. The course is split into 6 sessions, which will be completed in groups. The students will be assigned to groups at the beginning of the semester. 4 of the experiments will be geared towards the use case of designing a bone plate to bridge a critical size gap of a femur. The experiments are therefore 1) using CAD to reconstruct the initial condition and the bone plate 2) running a FEM in order to analyze the performance of the bone plate 3) with the knowledge of the FEM, optimizing the bone plate and 4) testing of the designed bone plate, the bone plate will be 3D printed. The remaining 2 experiments will 1) focus on programming a robotic arm used in rehabilitation engineering and 2) on the hardware usage of the robotic arm including force sensors and EMG.</td>
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<tr>
<td>Lecture notes</td>
<td>Each of the 6 sessions has its own tutorial and will be handed out to the students.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Only motivation and curiosity is required.</td>
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<tr>
<td>376-0002-01L</td>
<td>Product Design in Medical Engineering</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>S. J. Ferguson</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course will provide insight into various aspects of medical device design such as patient needs assessment, product specification, research and technical design, validation, regulatory affairs and clinical evaluation.</td>
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<tr>
<td>Objective</td>
<td>The goal of this lecture series is to enable the students to (i) identify the principal functional requirements for a medical device, (ii) to understand the mechanical properties of natural tissues and synthetic biomaterials, (iii) to apply this information and a basic knowledge of mechanics in the calculation of implant performance, (iv) to develop a plan for the pre-clinical evaluation and regulation of a new device.</td>
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</tbody>
</table>

#### Focus Courses

#### Human Movement Sciences and Sports

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Taylor, R. List</td>
</tr>
<tr>
<td>Abstract</td>
<td>Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.</td>
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<tr>
<td>Objective</td>
<td>Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.</td>
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<tr>
<td>Content</td>
<td>Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.</td>
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<tr>
<td>376-0207-00L</td>
<td>Exercise Physiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>C. Spengler, F. Gabe Beltrami</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors.</td>
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</tbody>
</table>
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenar discussions.

### Medical Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**

History of BME and the role of biomedical engineers. Ethical issues related to BME.

Biomedical sensors both wearable and also biochemical sensors.

Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.

Bioinformatics: genomics and proteomic tools, databases and basic calculations.

Equations describing basic reactions and enzyme kinetics.

Medical optics: Optical components and systems used in hospitals.

Basic concepts of tissue engineering and organ printing.

Biomaterials and their medical applications.

Function of the heart and the circulatory system.

Transport and exchange of substances in the human body, compartment modeling.

The respiratory system.

Bioimaging.

Orthopedic biomechanics.

Lectures (2h). discussion of practical exercises (1h) and homework exercises.

**Lecture notes**

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

moodle page of the course

**Prerequisites / notice**

No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
376-0021-00L  Materials and Mechanics in Medicine  
**W** 4 credits 3G  M. Zenobi-Wong, J. G. Snedeker

**Abstract**
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Objective**
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

**Content**
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

**Lecture notes**
course website on Moodle

**Literature**

376-1714-00L  Biocompatible Materials  
**W** 4 credits 3V  K. Maniura, M. Rottmar, M. Zenobi-Wong

**Abstract**
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**
Handouts are deposited online (moodle).

**Literature**

(available online via ETH library)

376-1220-00L  Rehabilitation and Inclusion  
**W** 3 credits 2G  R. Riener

**Abstract**
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

**Objective**
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenar discussions.
The course will cover the following topics:

- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Parasports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

#### Molecular Health Sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

**Abstract**

Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

This course focuses on the concepts of classical and modern genetics and genomics.

**Content**

- Introduction and historical background
- Inheritance and adaptive immunity, cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**

Scripts and additional material will be provided during the semester.
Cells undergo major functional alterations as we age. In this course, we will discuss the basic molecular and cell biological mechanisms of cellular ageing. We will also discuss diseases related to cellular ageing and current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

**Objective**
- Basic molecular and cell biological mechanisms of cellular ageing;
- Diseases related to cellular ageing;
- current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

**Content**
1. Lecture-1: Hallmarks of cellular ageing
2. Lecture-2: Cellular microenvironment & extra-cellular matrix
3. Lecture-3: Cell morphometric changes & cytoskeletal remodeling
4. Lecture-4: Proteostasis
5. Lecture-5: Mitochondrial dysfunction
6. Lecture-6: Endo-membrane signaling
7. Lecture-7: Nuclear signaling & epigenetic alternations
8. Lecture-8: Chromatin remodeling & gene expression
9. Lecture-9: Genomic integrity
10. Lecture-10: Ageing cell secretome and cellular homeostasis
11. Lecture-11: Diseases associated with cellular ageing
12. Lecture-12: Cellular rejuvenation strategies
13. Lecture-13: Therapeutic interventions to cellular ageing
14. Lecture-14: Concluding lecture

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### Neurosciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0007-01L</td>
<td>Advanced Neuroanatomy and Neurophysiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Willecke, S. Meissner, D. P. Wolfer</td>
</tr>
</tbody>
</table>

**Abstract**
Advanced knowledge of anatomy and physiology of the nervous system.

**Objective**

1. anatomy: How is the central nervous system structured?
2. motor control: which structures are involved in voluntary and involuntary movements?
3. sensory, somatosensory and sensorimotor integration: how is information from different systems integrated and interpreted by the brain?
4. Higher brain functions: What specializations enable us to speak and process emotions and feelings?

**Prerequisites / notice**

Während der Grundvorlesung (Anatomie und Physiologie 1) haben Sie bereits viele der in dieser Vorlesung behandelten Themen kennengelernt, allerdings nicht so detailliert. In dieser Vorlesung wird der Stoff der Grundvorlesung vertieft und erweitert. Es wird vorausgesetzt, dass Sie die in der Grundvorlesung besprochenen Inhalte bereits kennen. Der Stoff aus der Grundvorlesung wird nur teilweise repertiert.

Die Lektionen zur Neurophysiologie enthalten Einheiten des Selbststudiums. Dabei bearbeiten Sie Arbeitsaufträge in einem Polybook, um ein konzeptuelles Verständnis für die behandelten Themen zu entwickeln.

**Fostered competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: not assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed
- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed
- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: not assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1305-00L</td>
<td>Development of the Nervous System (University of Zurich)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.
Objective: On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development
- apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills: On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content: The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes: Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz as BIC0344

Prerequisites / notice: BIO142 Developmental Biology, BIO143 Neurobiology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1305-01L</td>
<td>Neural Systems for Sensory, Motor and Higher Brain Functions</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>G. Schratt, J. Bohacek, R. Fiore, R. Polania, W. von der Behrens, J. Winterer, further lecturers</td>
</tr>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
<td>Y. Barrat, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
</tbody>
</table>

Abstract: The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

Objective: The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.

Content: The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.

Literature: The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Bachelor Studies (Programme Regulations 2017)

Second Year Compulsory Courses

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract: Basic knowledge of the anatomy and physiology of tissues of the embryonal and postnatal development, the sensory organs, the neuromuscular system, the cardiovascular system and the respiratory system.

Objective: Basic knowledge of human anatomy and physiology and basics of clinical pathophysiology.

Content: The lecture series provides a short overview of human anatomy and physiology

Anatomy and Physiology I (fall term):
- Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system

Prerequisites / notice: Anatomy and Physiology II (spring term):
- digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.
- Requirements: 1st year, scientific part.
- Part of the course is read and checked in English.

401-0293-00L | Mathematics III | O | 5 credits | 3V+2U | A. Caspar, N. Hungerbühler |

Objective
Die Studierenden
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenfalls explizit berechnen: diskret/kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.

Content
Einführung Modellbildung
- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Lineare Modelle
- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen
- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle
- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Laplace-Transformation
- Definition und Notation
- Rechenregeln
- Anwendungsbeispiele

Lecture notes
Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Literature
- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Prerequisites / notice
Vorlesungen Mathematik I/II

Fostered competencies
Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: assessed
Problem-solving: assessed

Social Competencies
Cooperation and Teamwork: assessed

Personal Competencies
Creative Thinking: assessed
Critical Thinking: assessed

401-0643-13L Statistics II O 3 credits 2V+1U J. Dambon

Abstract
Vertiefung von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.

Objective

Exam Block

Number
402-0083-00L

Title
Physics I

Type
O

ECTS
4 credits

Hours
3V+1U

Lecturers
K. S. Kirch

Abstract
This course is an introduction to classical physics, with special focus on applications in medicine.

Content
Obtain an understanding of basic concepts in classical physics and their application (using mathematical pre-knowledge) to the solution of simple problems, including certain applications in medicine.
Obtain an understanding of relevant quantities and of orders of magnitude.

Lecture notes
Will be distributed at the start of the semester.

Literature
"Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann; De Gruyter Verlag.

Prerequisites / notice
Voraussetzung Mathematik I-II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin) / Mathematik-Lehrveranstaltungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)

Focus Courses

Human Movement Science and Sport

Number
402-0083-00L

Title
Physics I

Type
O

ECTS
4 credits

Hours
3V+1U

Lecturers
K. S. Kirch

Abstract
This course is an introduction to classical physics, with special focus on applications in medicine.

Content
Obtain an understanding of basic concepts in classical physics and their application (using mathematical pre-knowledge) to the solution of simple problems, including certain applications in medicine.
Obtain an understanding of relevant quantities and of orders of magnitude.

Lecture notes
Will be distributed at the start of the semester.

Literature
"Physik für Mediziner, Biologen, Pharmazeuten", von Alfred Trautwein, Uwe Kreibig, Jürgen Hüttermann; De Gruyter Verlag.

Prerequisites / notice
Voraussetzung Mathematik I-II (Studiengänge Gesundheitswissenschaften und Technologie bzw. Humanmedizin) / Mathematik-Lehrveranstaltungen des Basisjahres (Studiengänge Chemie, Chemieingenieurwissenschaften bzw. Interdisziplinäre Naturwissenschaften)

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1142 of 2416
376-0203-00L Movement and Sport Biomechanics  W  4 credits  3G  B. Taylor, R. List

Abstract
Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

Objective
Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.

Content
Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

376-0207-00L Exercise Physiology  W  4 credits  3G  C. Spengler, F. Gabe Beltrami

Abstract
This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems influencing factors, e.g. genetics, gender, age, altitude/deepth, heat/cold, with respect to performance and health.

Objective
The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/deepth, heat and cold on the named factors.

Content
History of Exercise Physiology, research methods, fibertype heterogeneity and its functional significance, neutral control of muscle force, molecular nad cellular mechanisms of muscle adaptation to resistance, endurance and stretching exercise, interindividual variability in the response to training, cardiorespiratory and metabolic responses to acute and chronic exercise, sex differences relevant to exercise performance, exercise in hot and cold environment, children and adolescents in sport and exercise, exercise at altitude and depth, aging and exercise performance, exercise for health, exercise in the context of disease.

Lecture notes
Online material is provided during the course.

Literature
Wird in der Vorlesung bekannt gegeben.

Prerequisites / notice
Anatomy and Physiology I + II

376-1220-00L Rehabilitation and Inclusion  W  3 credits  2G  R. Rienner

Abstract
This course presents origins and prevention of different physical, sensory, mental impairments, their treatments, and methods of assistance in public and home environments. Rehabilitation is put into a larger context providing insights into healthcare systems, health economy, accessibility, barrier-free architecture, para-sports, legal & regulatory aspects, disability policy, and inclusion.

Objective
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenary discussions.

Content
The course will cover the following topics:
- Introduction: definition of terms, historical and legal background, role of the UNO, WHO, ICRRC
- Origins: reasons and origins of physical, sensory and mental impairments; surgical and pharmaceutical treatments
- Therapy: physical therapy, occupational therapy, speech therapy, psychotherapy
- Technological support: Robot-aided therapy, Virtual Reality, muscle stimulation, Brain-Computer Interfaces (BCIs)
- Home therapy: personal assistance, mobile health systems, tele-monitoring, tele-therapy
- Assistive technologies: gait assistance, prosthesis, orthoses, seeing/hearing aids, etc.
- Social inclusion: definition of normality and belongingness, social behaviours, UN-BRK, etc.
- Accessibility: national and international aspects of accessibility
- Health economy in rehabilitation: public and private cost models, health insurance, SUVA, IV
- Barrier-free building and living: environmental obstacles, norms in architecture, inclusive design
- Parasports: history of Olympics and Paralympics, Special Olympics, Deaflympics, Cybathlon
- Policy: health, social, equal opportunity, disability
- Regulatory affairs: ethics committees, Swissmedic, Bundesamt für Gesundheit (BAG), law and disability
- Prevention: primary and secondary prevention, social prevention

Molecular Health Sciences

Number  Title  Type  ECTS  Hours  Lecturers

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
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<td>Information for UZH students:</td>
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<td>Enrolment to this course unit only possible at ETH. No enrollment to module BIG 348 at UZH.</td>
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<td>Please mind the ETH enrolment deadlines for UZH students: <a href="https://www.ethz.ch/en/studies/wwr-degree/courses/special-students-special-students-university-of-zurich.html">https://www.ethz.ch/en/studies/wwr-degree/courses/special-students-special-students-university-of-zurich.html</a></td>
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<td>Abstract</td>
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<td>Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<td>Objective</td>
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<td></td>
<td>This course focuses on the concepts of classical and modern genetics and genomics.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.</td>
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<td>Lecture notes</td>
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<td>Scripts and additional material will be provided during the semester.</td>
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| 551-0317-00L | Immunology | W    | 3    | 2V    | M. Kopf, A. Oxenius |
|             | Introduction into structural and functional aspects of the immune system. |      |      |       |                              |
|             | Basic knowledge of the mechanisms and the regulation of an immune response. |      |      |       |                              |
|             | Objective                       |      |      |       |                              |
|             | Introduction into structural and functional aspects of the immune system. |      |      |       |                              |
|             | Basic knowledge of the mechanisms and the regulation of an immune response. |      |      |       |                              |
Content

- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-Biol students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies not assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility not assessed
- Creative Thinking not assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Abstract
Cells undergo major functional alterations as we age. In this course, we will discuss the basic molecular and cell biological mechanisms of cellular ageing. We will also discuss diseases related to cellular ageing and current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Objective
- Basic molecular and cell biological mechanisms of cellular ageing;
- Diseases related to cellular ageing;
- current rejuvenation and therapeutic strategies for cellular ageing in health and disease.

Content
Lecture-1: Hallmarks of cellular ageing
Lecture-2: Cellular microenvironment & extra-cellular matrix
Lecture-3: Cell morphometric changes & cytoskeletal remodeling
Lecture-4: Proteostasis
Lecture-5: Mitochondrial dysfunction
Lecture-6: Endo-membrane signaling
Lecture-7: Nuclear signaling & epigenetic alternations
Lecture-8: Chromatin remodeling & gene expression
Lecture-9: Genomic integrity
Lecture-10: Ageing cell secretome and cellular homeostasis
Lecture-11: Diseases associated with cellular ageing
Lecture-12: Cellular rejuvenation strategies
Lecture-13: Therapeutic interventions to cellular ageing
Lecture-14: Concluding lecture

Medical Technology

Number Title Type ECTS Hours Lecturers
227-0386-00L Biomedical Engineering W 4 credits 3G J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.
### Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.

- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.

**Boimaging:** Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

### Literature

- Handouts and references therein.
- Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.
- Introduction to Biomedical Engineering, 3rd Edition 2011, J. G. Snedeker
- Materials and Mechanics in Medicine, W. 4 credits 3G. M. Zenobi-Wong, J. G. Snedeker
- Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective.
- The course covers the following topics:
  1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
  2. The concept of biocompatibility.
  3. Introduction into methodology used in biomaterials research and application.
  4. Introduction to different material classes in use for medical applications.

### Prerequisites

- No specific requirements, BUT
- ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
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<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>Self-awareness and Self-reflection</td>
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<td>Sensitivity to Diversity</td>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

### Prerequisites / notice

- **Moodle page of the course**
- **Lectures (2h), discussion of practical exercises (1h) and homework exercises.**
- **Introduction into different material classes in use for medical applications.**

### Lecture notes

- Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

### Literature

- Handouts are deposited online (moodle).

### Additional Information

- Academic Press
- Autumn Semester 2022
- Handouts are deposited online via ETH library

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1145 of 2416
With this lecture, we want to not only transfer a broad knowledge about rehabilitation and inclusion, but also raise awareness about the challenges and needs of people with impairments, the economy and the overall society. Students should learn about the complex and multi-faceted interaction of care, treatment, assistance, reimbursement, accessibility, legal regulation, and social inclusion. This knowledge and awareness should be presented in a multi-modal way using interactive tools and organizing group/plenary discussions.

### Neurosciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0007-01L</td>
<td>Advanced Neuroanatomy and Neurophysiology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Willecke, S. Meissner, D. P. Wolfer</td>
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<td></td>
<td>Advanced knowledge of anatomy and physiology of the nervous system.</td>
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<td>The course equips students with advanced knowledge of the anatomical structure and function of the most important structures of the central nervous system. They will understand pathophysiological mechanisms and identify explanations for the occurrence of specific symptoms in neurological diseases. They will also be able to apply their knowledge to describe the mechanism of action of drugs. In addition, they learn the most important methods for analyzing the functions of the nervous system and will be able to use this knowledge to evaluate experimental data.</td>
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<tr>
<td></td>
<td>1. anatomy: How is the central nervous system structured?</td>
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<td>2. motor control: which structures are involved in voluntary and involuntary movements?</td>
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<td>3. sensory, somatosensory and sensorimotor integration: how is information from different systems integrated and interpreted by the brain?</td>
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<td>4. Higher brain functions: What specializations enable us to speak and process emotions and feelings?</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-1305-00L</td>
<td>Development of the Nervous System (University of Zurich)</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>University lecturers</td>
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<tr>
<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: BIO344</td>
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<td>Mind the enrolment deadlines at UZH: <a href="https://www.uzh.ch/cmsssl/en/studies/application/deadline">https://www.uzh.ch/cmsssl/en/studies/application/deadline</a> s.html</td>
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</table>
Abstract
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Objective
On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills
On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
BIO142 Developmental Biology, BIO143 Neurobiology

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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</thead>
<tbody>
<tr>
<td>376-1305-01L</td>
<td>Neural Systems for Sensory, Motor and Higher Brain Functions</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
</tr>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td>W</td>
<td>6 credits</td>
<td>4V</td>
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**Electives**

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>151-0575-01L</td>
<td>Signals and Systems</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
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<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
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</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1147 of 2416
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

**Main topics of the course include:**
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical micro robots

**Lecture notes**
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

**Prerequisites / notice**
The lecture will be taught in English.

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<table>
<thead>
<tr>
<th>151-0917-00L</th>
<th>Mass Transfer</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>S. E. Pratsinis, V. Mavrantzas, C.-J. Shih</th>
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</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Fick’s laws; application and significance of mass transfer; comparison of Fick’s laws with Newton's and Fourier's laws; derivation of Fick’s 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Hilbert spaces, generalized functions, linear time-invariant systems, sampling theorems, discrete-time signals and systems, digital filter structures, Discrete Fourier Transform (DFT), finite-dimensional signals and systems, Fast Fourier Transform (FFT).</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.</td>
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<table>
<thead>
<tr>
<th>227-0045-00L</th>
<th>Signals and Systems I</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>H. Bölcskei</th>
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<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Introduction to mathematical signal processing and system theory.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Signal analysis in the time and frequency domains, signal spaces, Hilbert spaces, generalized functions, linear time-invariant systems, sampling theorems, discrete-time signals and systems, digital filter structures, Discrete Fourier Transform (DFT), finite-dimensional signals and systems, Fast Fourier Transform (FFT).</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Lecture notes, problem set with solutions.</td>
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<tr>
<th>327-0113-00L</th>
<th>Foundations of Materials Science I</th>
<th>W</th>
<th>2 credits</th>
<th>2G</th>
<th>L. Isa</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The basic physical concepts for the description of materials are taught, partly in self-study, and applied in exercises. Basic atomistic and macroscopic concepts (e.g. phase diagrams, phase transformations, response functions) are introduced through examples. Selected topics are deepened in classroom lectures.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Students are able to</td>
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<td>- name the basic concepts of materials science. (remember, 1)</td>
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<td>- describe simple relations between atomic structure and macroscopic properties. (understand, 2)</td>
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<td>- calculate basic material-specific quantities. (apply, 3)</td>
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<td>- read and interpret phase diagrams, material characteristic (e.g. stress-strain) diagrams and Ashby plots (analyse, 4)</td>
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<tr>
<td><strong>Content</strong></td>
<td>Atomic structure</td>
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<td></td>
<td>Crystalline structure and defects</td>
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<td></td>
<td>Thermodynamics, phase diagrams and phase transformations</td>
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<td></td>
<td>Diffusion</td>
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<td></td>
<td>Mechanical and thermal properties of materials</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>376-0130-00L</th>
<th>Laboratory Course in Exercise Physiology</th>
<th>W</th>
<th>4 credits</th>
<th>4P</th>
<th>C. Spengler</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of physical activity and climatic influences. Learn fundamental assessment techniques of the muscular system, the cardio-respiratory system and of whole-body performance, learn scientifically correct data analysis and interpretation of results. Insight into today's Sports Medicine.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Laboratory course: Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Cooper-Test).</td>
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</tbody>
</table>
Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to provide instructional materials for each course. All lecture materials will be available to students on Moodle.


**History of Sports**

This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.

O. Hämmig

**Objective**

Understanding for the development and adaptation of sports from the ancient world to present times.

**Content**


**Sport Pedagogy**

The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on "pedagogical-psychological aspects of competence development in the context of a multi-perspective physical education".

C. Herrmann

**Objective**

Development of pedagogical-psychological competences for the optimisation of future teaching activities.

**Content**

- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

Lecture notes: Teaching materials for the individual lectures are provided to the students via moodle.


**Sport Psychology**

This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.

H. Gubelmann

**Objective**

Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to present the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students' expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.

**Content**

- Introduction to sport psychology
- Cognitions in sports: mental rehearsal and mental training
- Emotions and stress
- Motivation: goal-setting in sports
- Career and career transition in elite sport
- Coach-Athlete-Interaction
- Psychological aspects of sport-injury rehabilitation
- Group dynamics in sport

Lecture notes: Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle.


Content

From a public health perspective, there are a number of social circumstances that have a high potential for disease and even increased risk of mortality for the affected populations.

These major social health risks include the following:
- unemployment and social decline
- poverty and social deprivation
- loneliness and social isolation
- migration and social discrimination
- Over-indebtedness and social marginalization
- risky behavior and unhealthy social lifestyles

Such living conditions and behaviors have been shown to cause increased health risks, but do not necessarily mean that all those affected have comparatively poor health or low life expectancy. Potentially affected individuals, however, do fundamentally represent health risk groups, which include the following groups of people:
- (long-term) unemployed, disenabled, welfare recipients, etc.
- those at risk of and affected by poverty, including homeless, low-income, working poor, single parents, etc.
- Lonely or solitary people and the socially disintegrated
- Refugees, immigrants, foreigners, secondos, etc.
- heavily indebted, insolvent people, people affected by wage garnishment, private bankruptcy, etc.
- addicts (incl. drug, alcohol, gambling and work addicts), underweight or overweight and obese, sedentary and physically inactive people, etc.

Prerequisites / notice

Willingness to regularly attend and actively participate in the course.

<table>
<thead>
<tr>
<th>376-1127-00L</th>
<th>Sociology of Sport</th>
<th>W</th>
<th>2 credits</th>
<th>2V</th>
<th>R. Bürgi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>The lectures set out to:</td>
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<tr>
<td></td>
<td>present the different dimensions, functions and interrelationships of present-day sport</td>
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<td></td>
<td>provide an introduction to the central theories and models of (sport) sociology</td>
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<td>show how far sport reflects society and how it changes and becomes more differentiated in the process</td>
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<td>take current examples to highlight the sociological view of sport.</td>
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<tr>
<td>Content</td>
<td>Sport and social change: developments and trends</td>
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<td></td>
<td>The economy and the media: dependencies, consequences, scandals</td>
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<tr>
<td></td>
<td>Social inequalities and distinctions: gender differences and group behavior</td>
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<tr>
<td>Literature</td>
<td>Selected materials for the lecture are available on the Moodle platform.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories</td>
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<tr>
<td>Fostered competencies</td>
<td>Method-specific Competencies: Analytical Competencies</td>
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<tr>
<td>Fostered competencies</td>
<td>Social Competencies: Sensitivity to Diversity</td>
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<tr>
<td>Fostered competencies</td>
<td>Personal Competencies: Critical Thinking</td>
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</table>

<table>
<thead>
<tr>
<th>376-1581-00L</th>
<th>Cancer: Fundamentals, Origin and Therapy</th>
<th>W</th>
<th>2 credits</th>
<th>2G</th>
<th>H. Nägeli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process. Classes of chemical compounds that induce cancer are discussed as well as the reactive metabolites that may be built from. Covalent binding to DNA is discussed and different types of mutations resulting thereof. A selection of proto-oncogenes and tumor suppressor genes is presented. Their function will be discussed as well as the changes which are found in these genes in tumor cells, starting from single nucleotide exchanges up to large deletions. The reason for genetic predisposition to cancer will be discussed as well as cancer relevant aspects of cell cycle regulation. The role of tumor microenvironments and phenomena like angiogenesis and metastasis are presented as well as the mechanisms that protect the genome from mutagenic damage. Further subjects address old and new strategies of cancer treatment. Personalised cancer treatment.</td>
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<tr>
<td>Objective</td>
<td>Students are able to describe selected chemicals, biological and molecular processes that occur in cells spontaneously or after physical or chemical exposure and resulting in a tumor. They are able to list important cancer-inducing agents and explain the respective mechanism of action. They have knowledge of significant risk factors for cancer diseases. They are confronted with the basics of toxicology and they can explain the principle of the most common therapeutic strategies.</td>
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<tr>
<td>Content</td>
<td>The economy and the media: dependencies, consequences, scandals</td>
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<td></td>
<td>Social inequalities and distinctions: gender differences and group behavior</td>
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<tr>
<td>Literature</td>
<td>Handouts with reproductions of all presented transparencies will be distributed.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories</td>
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<tr>
<td>Fostered competencies</td>
<td>Method-specific Competencies: Analytical Competencies</td>
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<tr>
<td>Fostered competencies</td>
<td>Social Competencies: Sensitivity to Diversity</td>
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<tr>
<td>Fostered competencies</td>
<td>Personal Competencies: Critical Thinking</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1150 of 2416
2V
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain

A. Blasimme

Adaptability and Flexibility
Communication

Grundlagen der Diagnostik, Anamnese,
Ethics of Life Sciences and Biotechnology

Basics of Exercise Therapy
Does not take place this semester.
Number of participants limited to 30.

376-1715-00L
Basics of Exercise Therapy
W 2 credits 2V

A: diagnostic, anamnesis, diagnostic of movement and function, assessments in exercise therapy, diagnostic of experience and behavior in

B: biological-medical basics, pathophysiologische Basics (internal, orthopedic and psychological deseases.

C: didactic knowledge, Reha-didactic

Students learn the assessments to plan an exercise-therapy-treatment. They are able to use them. They're able to integrate biological and medical basics.

Grundlagen der Diagnostik, Anamnese,
Bewegungsdagnostik, Funktionsdiagnostik
Sport- und Bewegungstherapeutische Testverfahren
Motorische Basisdiagnostik
Diagnostik bewegungsbezogenen Erlebens und Verhaltens
Biologisch-medizinische Grundlagen
Biomechanik (v.a. Gelenke), Pathophysiologische Grundlagen, Modelle der Methodik und Didaktik, Lektionsplanung

Lecture notes
Literature
Prerequisites / notice

Possible from the 5th semester on. Requirement: 376-1715-00L "Introduction to Exercise Therapy" passed.

A: diagnostic, anamnesis, diagnostic of movement and function, assessments in exercise therapy, diagnostic of experience and behavior in

B: biological-medical basics, pathophysiologische Basics (internal, orthopedic and psychological deseases.

C: didactic knowledge, Reha-didactic

Students learn the assessments to plan an exercise-therapy-treatment. They are able to use them. They're able to integrate biological and medical basics.

Grundlagen der Diagnostik, Anamnese,
Bewegungsdagnostik, Funktionsdiagnostik
Sport- und Bewegungstherapeutische Testverfahren
Motorische Basisdiagnostik
Diagnostik bewegungsbezogenen Erlebens und Verhaltens
Biologisch-medizinische Grundlagen
Biomechanik (v.a. Gelenke), Pathophysiologische Grundlagen, Modelle der Methodik und Didaktik, Lektionsplanung

Lecture notes
Literature
Prerequisites / notice

90% of the lections students must be present.

open-book-test in the last sessions at 20.12.2017
Applied Basics in Sports and Exercise Therapy

W 2 credits 2V

Does not take place this semester.
Number of participants limited to 30.

Possible from the 5th semester on. Requirement: 376-1715-00L "Introduction to Exercise Therapy" passed.

Abstract
Communication skills and methods of psychoregulation applied to the area of Exercise and Sports Therapy.

Objective
The students are able to plan, lead through and evaluate conversations with patients.
The students are familiar with a specific method of psychoregulation.
The participants know different aspects of relationship formation (therapist/client) in therapeutic work.

Content
Communication and conversation: client-centered forms of conversation in theory and practice
Psychoregulative Methods: Theoretical and practical insight into various psychoregulative methods

Lecture notes
Documents will be distributed two weeks before lecture.

Prerequisites / notice
The courses "Exercise and Sports Therapy 1 and 2" have been completed successfully.
A minimum of 90% of attendance if used as credits towards CAS SVGS.
One seminar day in an institution/company specialized in reintegration of clients into the workforce.

Spinal Cord Injury and Exercise
Prerequisite: Anatomy and Physiology

W 2 credits 2V C. Perret

Abstract
Intensive discussion concerning complications of a spinal cord injury and their consequences on trainability and exercise performance of persons sitting in a wheelchair. Overview on the clinical application of exercise testing as well as on the implementation of sport scientific findings to optimise performance of individuals with spinal cord injury in rehabilitation and elite sports.

Objective
Knowledge of the pathophysiology and the concomitant complications of a spinal cord injury and the consequences for physical exercise and trainability during rehabilitation as well as in recreational and elite sport.

Content
The following issues will be discussed: Epidemiology and etiology of spinal cord injury; complications and consequences of spinal cord injury; trainability/exercise physiology and spinal cord injury; history and organisation of wheelchair sports; elite sport and spinal cord injury

Literature
General literature:
H.G. Koch, V. Geng
Querschnittlähmung verständlich erklärt (Band 1 und Band 2)
Selbstverlag Manfred-Sauer-Stiftung und Schweizer Paraplegiker-Vereinigung
ISBN 978-3-00-069888-0 (Band 1) und 978-3-00-069889-7 (Band 2)

G.A. Zäch, H. G. Koch
Paraplegie - ganzheitliche Rehabilitation
Karger-Verlag, 2006
ISBN 3-8055-7980-2

V. Goosey-Tolfrey
Wheelchair sport: A complete guide for athletes, coaches and teachers
Human Kinetics, 2010

Y.C. Vanlandewijck, W.R. Thompson
The Paralympic Athlete
Wiley-Blackwell, 2011
ISBN 978-1-4443-3404-3

Liz Broad
Sports Nutrition for Paralympic Athletes, Second Edition
CRC Press 2019

Y.C. Vanlandewijck, W.R. Thompson
Training and Coaching the Paralympic Athlete
ISBN 978-1-119-04433-8

Nucleic Acids and Carbohydrates

W 6 credits 3G

Note for BSc Biology students: Only one of the two concept courses 529-0731-00 Nucleic Acids and

K. Lang, P. A. Kast, S. J. Sturla, H. Wennemers
Abstract Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Objective Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Content Structure, function and chemistry of nucleic acids and carbohydrates. DNA/RNA structure and synthesis; recombinant DNA technology and PCR; DNA arrays and genomics; antisense approach and RNAi; polymerases and transcription factors; catalytic RNA; DNA damage and repair; carbohydrate structure and synthesis; carbohydrate arrays; cell surface engineering; carbohydrate vaccines

Lecture notes No script; illustrations from the original literature relevant to the individual lectures will be provided weekly (typically as handouts downloadable from the Moodle server).

Literature Mainly based on original literature, a detailed list will be distributed during the lecture

Fostered competencies Subject-specific Competencies Concepts and Theories assessed Techniques and Technologies assessed
Method-specific Competencies Analytical Competencies assessed Problem-solving assessed
Social Competencies Communication assessed Cooperation and Teamwork assessed
Personal Competencies Self-awareness and Self-reflection assessed Self-direction and Self-management assessed

535-0230-00L Medicinal Chemistry I W 2 credits 2V J. Hall

Abstract The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

Lecture notes Will be provided in parts before each individual lecture.


Prerequisites / notice Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.

535-0521-00L Pharmacology and Toxicology I W 3 credits 2V U. Quitterer, J. Abd Alla

Abstract This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

Objective The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

Content Topics include disease-relevant macroscopic, microscopic, pathobiochemical and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicity, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

Lecture notes A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

Literature Recommended reading:

- or 14th Edition (expected Dec. 2022)

Prerequisites / notice Voraussetzungen: Abschluss Grundstudium

535-0810-00L Gene Technology W 2 credits 2G K. Eyer, J. Scheuermann

Abstract The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

Objective The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the-art of the methods of applications and publications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1153 of 2416
Content

I) Genomics and transcriptomics

Methods and Techniques:
- Recombinant DNA technology
- Next generation sequencing methods, sequencing of genomes
- CRISPR technology

Application to human biology:
- Functional genomics/transcriptomics
- Principles of cancer, genetic diseases
- Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

II) Proteomics

Methods and Techniques:
- Protein cloning and expression
- The antibody molecule
- Measurement and determination of biomolecular interactions
- Protein characterization and engineering
- Modifications and radioactive labelling

Application to human biology:
- Protein therapeutics
- Proteomic approaches for identification of novel disease-related targets and biomarkers

III) Drug discovery: Protein-based libraries

- Immune repertoire mining
- Display and selection technologies
  1. antibody phage display
  2. other polypeptide display technologies
  3. small-molecules display: DNA-encoded chemical libraries

Lecture notes

The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Decision-making assessed
- Problem-solving assessed

Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed

535-0830-00L
Pharmaceutical Immunology
W 2 credits 2G C. Halin Winter, V. Collado Díaz

Abstract
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Objective
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Content
Chapters 1 - 11 of the Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition; Garland).

Literature
Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition).

Paperback [www.garlandscience.com]

551-0319-00L
Cellular Biochemistry (Part I)
W 3 credits 2V U. Kutay, G. Neurohr, M. Peter, I. Zemp

Abstract
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth.

Objective
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signalling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content
- Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.
- Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes
Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

557-0215-00L
Professional Exercises
W 2 credits 4G to be announced

Abstract
The course will only take place with 12 or more registrations.

BSc HST students with a J+S-Coach certificate can take the course from 3rd semester onwards, others from 5th semester onwards. 3rd semester students, please send a copy of your J+S-Coach certificate to the study administration HST (hst@hest.ethz.ch).

Students apply teaching methods they learned in Didactics I and II in practical lessons in the gym hall. They also supervise their fellow students and give feedback.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>Tutor(-s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-2120-00L</td>
<td>Consumer Behaviour I</td>
<td>W</td>
<td>1 credit</td>
<td>M. Siegrist, A. Bearth, A. Berthold</td>
</tr>
<tr>
<td>752-4005-00L</td>
<td>Food Microbiology I</td>
<td>W</td>
<td>3 credits</td>
<td>M. Loesner</td>
</tr>
</tbody>
</table>

**Objective**

**Content**

**Literature**

**Prerequisites / notice**

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## ETH Week 2022: Urban Futures

**Abstract**

This one-week course is designed to foster critical thinking and creative learning. Students from all departments, as well as professors and external experts, will work together in interdisciplinary teams. The course will focus on developing interventions that could play a role in solving some of our most pressing global challenges. In 2022, ETH Week will focus on the topic of urban development.

- Domain-specific knowledge: Students have immersed knowledge about specific complex societal topic selected every year.

- Food Microbiology I: This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of different bacteria, yeasts, molds, and foodborne pathogens and spoilage organisms. The focus of this part of the lecture will be on the organisms, but also on the factors which determine spoilage and foodborne disease.
Gives the students background knowledge necessary for a basic understanding of the complex relationships between food composition

Handouts for each lecture will be uploaded to Moodle every week.

Recommendations will be given in the first lecture

To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during

Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

1. To introduce the students to the both macro- and micronutrients in relation to food and metabolism.

F. von Meyenn

Lecture slides and required handouts will be available on the ETH website (moodle).

2V, C. Wolfrum, E. Gasser

The course is divided into two parts. The lectures on micronutrients are given by Prof. Zimmermann and the lectures on macronutrients

The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy

W, M. B. Zimmermann

Introduction to Nutritional Science

752-6001-00L

Abstract
This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble

vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient
digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

Objective
To introduce the students to both macro- and micronutrients in relation to food and metabolism.

Content
The course is divided into two parts. The lectures on micronutrients are given by Prof. Zimmermann and the lectures on macronutrients

are given by Prof. Wolfrum. Prof. Zimmermann discusses the micronutrients, including fat-soluble vitamins, water-soluble vitamins,

minerals and trace elements. Prof. Wolfrum introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism.

The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeorhesis are

emphasized.

Lecture notes
There is no script. Powerpoint presentations will be made available.

Literature
Elmadfa I & Leitzmann C: Ernährung des Menschen
UTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004

Garrow JS and James WPT: Human Nutrition and Dietetics
Churchill Livingstone, Edinburgh, 11th rev. ed. 2005

Introduction to Nutritional Science

752-6001-00L

Nutrition-Related Physiology

W 3 credits 2V  M. B. Zimmermann, C. Wolfrum

Abstract
Gives the students background knowledge necessary for a basic understanding of the relationship between food composition and

nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand.

Objective
Some basic knowledge in physiology is recommended for this course, which revisits important physiological topics, emphasizing their

relation to nutrition. The aim is to give the students background knowledge necessary for a basic understanding of the complex relationships

between food composition and nutrition on one hand and the functioning, as well as the malfunctioning, of major organ systems on the other hand. For students with a background in medicine, pharmacy or biology, the course is useful as a review of previously acquired knowledge. Major topics are basic neuroanatomy and neurophysiology; general endocrinology; the physiology of taste and smell; nutrient digestion and absorption; intermediary metabolism and energy homeostasis; and some aspects of cardiovascular physiology and water balance.

Lecture notes
Handouts for each lecture will be uploaded to Moodle every week.

Nutrition and Performance

W 2 credits 2V  S. Mettler, M. B. Zimmermann

Abstract
The course introduces basic concepts of the interaction between nutrition and exercise performance.

Objective
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during

and after exercise.

Content
The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy

metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how

exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

Lecture notes
Lecture slides and required handouts will be available on the ETH website (moodle).

Literature
Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

Prerequisites / notice
General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on

basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

► Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1156 of 2416
### Language Courses

*see Science in Perspective: Language Courses ETH/UZH*

### Sports Practice

- **Sport Practical Basic Education**
- **Sport Practical Advanced Education**

#### Assessments

### Health Sciences and Technology Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Eligibility</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td></td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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### Key for Hours

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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching. This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Abstract
This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective
Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content
Thematische Schwerpunkte:
Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzentwicklung unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:

Lecture notes
Folien werden zur Verfügung gestellt.

Literature

Prerequisites / notice
This course is only apt for students who intend to enrol in the programs “Lehrdiplom” or “Didaktisches Zertifikat”. It is about learning in childhood and adolescence.

Abstract
In this class, students will learn concepts and skills for coping with psychosocial demands of teaching

Objective
Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.

(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

Prerequisites / notice
Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

Abstract
This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice
Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

Abstract
This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.

Objective
Students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Prerequisites / notice
The successful participation in EW1 (“Human Learning”) and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.

Abstract
This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.

Objective
Students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Prerequisites / notice
Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

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Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Abstract
The focus will be on the book “Intelligenz: Grosse Unterschiede und ihre Folgen” by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

Objective
- Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

Prerequisites / notice
The successful participation in EW1 (“Human Learning”) and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.

Abstract
This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.

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Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

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This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.

Objective
Students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Prerequisites / notice
Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Abstract
This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”.

Objective
Students will intensively work on, refine and optimize a teaching unit following a goal set in advance.
Gender Issues In Education and STEM

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

Abstract
Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective
- Students know how to prepare, conduct and reflect a single lesson based on educational requirements.
- Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the ambitions of the learners.
- Students take the learning goals as a starting point considering previous knowledge as well as the professional environment and the ambitions of the learners.
- Students apply the basic teaching techniques of their subject area in a sensible way and know how to appropriately arrange the phases of learning.
- Students know how to simplify and present complex technical contents of their subject area.

Content
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

Formation of Knowledge in STEM Fields in Primary and Secondary School

Abstract
The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

Content
Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

Number Didactics and Professional Training

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-8001-00L</td>
<td>Didactics of Health Sciences and Technology I</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>S. Maurer, S. Sinistaj</td>
</tr>
</tbody>
</table>

Enrolment at the earliest possible with the lecture 851-0240-00L Human Learning.

Objective
In this course students learn the principles and techniques of teaching singular lessons, based on scientific knowledge about learning. The aim is to plan, realize, evaluate and reflect lessons effectively and efficiently.

Objective
- Students know how to prepare, conduct and reflect a single lesson based on educational requirements.
- Students take the learning goals as a starting point considering previous knowledge as well as the professional environment and the ambitions of the learners.
- Students apply the basic teaching techniques of their subject area in a sensible way and know how to appropriately arrange the phases of learning.
- Students know how to simplify and present complex technical contents of their subject area.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

376-8008-00L Teaching Internship Including Examination Lessons
Health Sciences and Technology
Only for Health Sciences and Technology TC students.

The teaching internship can just be visited if all other courses of TC are completed.
Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

Abstract
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They learn to assess pupils' work.
- They learn to assess pupils' work.
- They learn to assess pupils' work.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

376-8011-00L Mentored Work Subject Didactics Health Sciences and Technology
Only for Health Sciences and Technology TC students.

Abstract
The mentored paper is designed to bring together the findings from the FD1 and the FD2. By using various teaching techniques and methods a semester plan, which is based on various curricula will be elaborated for a given topic.

Objective
1. The students have planned a curriculum for a semester course.
2. Students reflect on formative and summative ways such a teaching unit to examine and implement parts of it.
3. The students have implemented parts of the semester curriculum.
4. The students deal with the question to what extent teaching techniques, teaching methods but also sequences of self-study must be involved in the planning.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1160 of 2416
### Compulsory Courses

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>376-0300-00L</td>
<td>Translational Science for Health and Medicine</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfrum</td>
</tr>
</tbody>
</table>

**Abstract**

Translational science is a cross-disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basic features of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

**Objective**

After completing this course, students will be able to understand:
- Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)
- How independent is translational science?
- Academic boundary conditions vs. industrial influences

**Content**

- What is translational science and what is it not?
- How to identify need?
- Disease concepts and consequences for research
- Basics about incidence, prevalence etc. and orphan indications
- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources
- How to measure success?
- Outcome variables
- Improving the translational process
- Challenges of communication?

**GCP Basic Course (Modules 1 and 2)**

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<tr>
<th>Number</th>
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<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>376-0302-01L</td>
<td>GCP Basic Course (Modules 1 and 2)</td>
<td>O</td>
<td>1</td>
<td>1G</td>
<td>G. Senti, C. Fila, R. Grossmann</td>
</tr>
</tbody>
</table>

**Abstract**

The basic course in “Good Clinical Practice” (GCP) contains two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

**Objective**

Students will get familiar with:
- Key Ethics documents
- (International) Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

**Content**

Module 1:
- Research and Research Ethics, Guidelines, (inter)national Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
- Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

### Electives

#### Electives Courses I

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<tr>
<th>Number</th>
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<tr>
<td>376-0221-00L</td>
<td>Methods and Concepts in Human Systems Neuroscience and Motor Control</td>
<td>W</td>
<td>4</td>
<td>3P</td>
<td></td>
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</tbody>
</table>

**Abstract**

This course provides hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (nerve/brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students read scientific material, set up experiments, perform measurements in the lab, analyse data, apply statistics and write short reports or essays.

**Objective**

This course will prepare students for experimental work as it is typically done during the master thesis. The goal is to gain hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (for example peripheral nerve stimulation, electrical and magnetic brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students will learn how to perform small scientific projects in this area. Students will work individually or in small groups and solve scientific problems which require them to perform measurements in human participants, extract relevant readouts from the data, apply appropriate statistics and interpret the results. They will also be required to write small essays and reports and they will get feedback on their writing throughout the course.

**Prerequisites / notice**

Students are required to have successfully completed the course “Neural control of movement and motor learning” and to have basic knowledge of applied statistics.

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>376-0223-00L</td>
<td>Advanced Topics in Exercise Physiology</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>C. Spengler, G. D'Hulst, F. Gabe Beltrami</td>
</tr>
</tbody>
</table>

**Abstract**

In this course, students read, present and discuss seminal publications in the area of exercise physiology. The focus lies on critical analysis of scientific content, conceptual as well as ethical aspects of publications. Students are trained in the most common scientific presentation techniques such as oral and poster presentations.
Elective Courses II

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0385-10L</td>
<td>Biomedical Imaging</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>S. Közerke, K. P. Prüssmann</td>
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</tbody>
</table>

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications
Abstract

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective

Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content

History of BME and the role of biomedical engineers. Ethical issues related to BME.

Biomedical sensors both wearable and also biochemical sensors.

Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.

Bioinformatics: genomic and proteomic tools, databases and basic calculations.

Equations describing basic reactions and enzyme kinetics.

Medical optics: Optical components and systems used in hospitals.

Basic concepts of tissue engineering and organ printing.

Biomaterials and their medical applications.

Function of the heart and the circulatory system.

Transport and exchange of substances in the human body, compartment modeling.

The respiratory system.

Bioimaging.

Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes

Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

Prerequisites / notice

No specific requirements, BUT

ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Techniques and Technologies assessed

Concepts and Theories

Image Analysis and Computer Vision

<table>
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<th>W</th>
<th>credits</th>
<th>V+U</th>
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<td>Image Analysis and Computer Vision</td>
<td>6</td>
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</table>

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Prerequisites:
- Basic concepts of mathematical analysis and linear algebra.
- The computer exercises are based on Python and Linux.

The course language is English.

Microscopy Training SEM I - Introduction to SEM

<table>
<thead>
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<th>Title</th>
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<td>Microscopy Training SEM I - Introduction to SEM</td>
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Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications.

This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.
The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterion
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers.

F. Hacklin

Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Objective

This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures.

Content

12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

F. Da Conceição Barata

Developing Digital Biomarkers

Particularly suitable for students with a technical background who are interested in healthcare.

Abstract

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers.

More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients.

However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:
• understand the anatomy of digital biomarkers
• understand the potential and applications of digital biomarkers
• be able to critically reflect and assess existing digital biomarkers
• be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have pushed the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.
Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of

Multiscale Bone Biomechanics

B. Taylor

Material will be provided on Moodle and eColab.


Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

376-0121-00L Multiscale Bone Biomechanics

W 6 credits 4S R. Müller, X.-H. Qin

Number of participants limited to 30

Abstract

The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

Objective

The learning objectives are:
1. advanced knowledge of the state-of-the-art in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python;
6. hands on experience in design and customizing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Content

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.

To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions Courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material for the lecture part of the posted questions (Q&A). Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

Lecture notes

Material will be provided on Moodle and eColab.

Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

376-0130-00L Laboratory Course in Exercise Physiology

W 4 credits 4P C. Spengler

Number of participants limited to 48

Abstract

Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

Objective

Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of physical activity and climatic influences. Learn fundamental assessment techniques of the muscular system, the cardio-respiratory system and of whole-body performance, learn scientifically correct data analysis and interpretation of results. Insight into today's Sports Medicine.

Content

Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test), dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.

Lecture notes

Tutorial on Laboratory Experiments in Exercise Physiology

(Editor: Exercise Physiology Lab)

Literature

Schmidt/Lang/Heckmann: Physiologie des Menschen, Springer-Verlag, Heidelberg

Kenney/Wilmore/Costill: Physiology of Sport and Exercise, Human Kinetics

Prerequisites / notice

Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)

Desirable: Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)

376-0203-00L Movement and Sport Biomechanics

W 4 credits 3G B. Taylor, R. List

HST: Possible from the 5th semester on.

Abstract

Conduct physical performance tests and measurements that are typically used to assess performance of athletes and/or patients and that deepen the understanding of physiological processes in response to physical exertion.

Objective

Gain hands-on experience in exercise physiology and consolidate knowledge on physiological adaptations to different types and degrees of physical activity and climatic influences. Learn fundamental assessment techniques of the muscular system, the cardio-respiratory system and of whole-body performance, learn scientifically correct data analysis and interpretation of results. Insight into today's Sports Medicine.

Content

Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test), dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.

Lecture notes

Tutorial on Laboratory Experiments in Exercise Physiology

(Editor: Exercise Physiology Lab)

Literature

Schmidt/Lang/Heckmann: Physiologie des Menschen, Springer-Verlag, Heidelberg

Kenney/Wilmore/Costill: Physiology of Sport and Exercise, Human Kinetics

Prerequisites / notice

Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)

Desirable: Exercise Physiology Lecture (concomitantly or passed; is selection criterion in case of more applications than lab spaces)
Exercise Physiology

Objective

Students are able to describe the human body as a (bio-)mechanical system.

Content

Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects

Objective

The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Content

The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

- **Topic 1**: Molecular pathways that control muscle stem cell self-renewal and differentiation
- **Topic 2**: Genome engineering to correct genetic mutations that cause muscle diseases
- **Topic 3**: Muscle fiber composition, force production and insulin sensitivity
- **Topic 4**: Amino acid sensitivity in skeletal muscle following exercise

Prerequisites / notice

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

Applied Human Research Project Management

Objective

The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Create/select well-founded research hypothesis and study designs for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects
- Integrate principles of effective communication in speaking, writing and graphical illustrations of future research idea/output
The course will cover the following topics:

- Introduction to different study designs and ethical requirements thereof in Switzerland
- Introduction to literature search and searching platforms
- How to collect and sort publications/ keep up to date on research topic
- Inputs on critically evaluating papers
- How to pre-define study requirements to "future-proof" the research (hypothesis, sample size definition, pre-registration)
- Correct conduction of fundamental human research procedures (e.g., screening, consent process, CRF) and identification/prevention of deviations and emergencies (e.g., SAE/AE, protocol violation, research misconduct)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metafiles)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

### History of Sports

**376-1033-00L**

**W 2 credits 2V  M. Gisler**

**Abstract**

Comprehension for development and changes of sports from the ancient world to the presence. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day.

**Objective**

Understanding for the development and adaptation of sports from the ancient world to present times.

**Content**


**Lecture notes**

Ein Skript für die aktuelle Veranstaltung wird abgegeben.

**Literature**

Primärliteratur:


**Primärliteratur**


**Sport Pedagogy**

**376-1107-00L**

**W 2 credits 2V  C. Herrmann**

**Abstract**

The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on "pedagogical-psychological aspects of competence development in the context of a multi-percussive physical education".

**Objective**

Development of pedagogical-psychological competences for the optimisation of future teaching activities.

**Content**

- Subject area of educational psychology
- Motivating students in physical education
- Building self-efficacy and strengthen the self-concept
- Promoting positive emotions and a positive attitude to anxiety
- Encouraging self-directed learning
- Leading classes and promoting cooperation
- Communicating with students efficiently
- Reflecting your own expectations critically
- Handling gender issues sensitively
- Promoting inclusion / Strengthening social and moral development
- Dealing with difficult students
- Evaluating achievements of students

**Lecture notes**

Teaching materials for the individual lectures are provided to the students via moodle.

**Literature**

Primärliteratur:


**Sport Psychology**

**376-1117-00L**

**W 2 credits 2V  H. Gubelmann, C. Baldassarre Ackermann, P. Müller**

**Abstract**

This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.

**Objective**

Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students' expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.

**Content**

Main Topics
- Introduction to sport psychology
- Cognitions in sports: mental rehearsal and mental training
- Emotions and stress
- Motivation: goal-setting in sports
- Career and career transition in elite sport
- Coach-Athlete-Interaction
- Psychological aspects of sport-injury rehabilitation
- Group dynamics in sport

**Lecture notes**

Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle.

**Literature**


**Sociology of Sport**

**376-1127-00L**

**W 2 credits 2V  R. Bürgi**

**Abstract**

These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.

**Objective**

The lectures set out to:
- present the different dimensions, functions and interrelationships of present-day sport
- provide an introduction to the central theories and models of (sport) sociology
- show how far sport reflects society and how it changes and becomes more differentiated in the process
- take current examples to highlight the sociological view of sport.

**Content**

Sport and social change: developments and trends
- The economy and the media: dependencies, consequences, scandals
- Social inequalities and distinctions: gender differences and group behavior
- Conflicts and politics: sports organizations, doping, violence

**Lecture notes**

Selected materials for the lecture are available on the Moodle platform.
**Literature**

A detailed program with additional references will be delivered at the beginning of the lecture.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</table>

**376-1151-00L Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging**

**Number of participants limited to 30**

**Abstract**
Recently, several start-up companies are aiming to translate basic molecular findings into new drugs/therapeutic interventions to slow aging or post-pone age-related diseases (e.g., Google founded Calico or Craig Ventier's Human Longevity, Inc.). This course will teach students the basic skill sets to formulate their own ideas, design experiments to test them and explains the next steps to translate these ideas.

**Objective**
The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention.

Learning objectives include:
1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
2. Analyse/compare current molecular/genetic strategies that address these aging problems.
3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.

**Content**
Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.

No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.

**376-1176-00L Wearable and Mobile Technologies of the Future - Focus on Sports and Health**

**Number of participants limited to 60**

**Abstract**
This course focuses on the progress in the field of wearable and unobtrusive technologies for sports and health. Topics as monitoring heart health and blood pressure, biofeedback and improvement of motor skills and performance are covered. The focus lies on learning about the principles and design of the new generation of non-invasive technologies in fitness-, athletic and medical applications.

**Objective**
Objective 1: Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: Acquire skills to design novel non-invasive technologies for sport and health.

**Content**
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/ or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

**376-1177-00L Human Factors I**

**Abstract**
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people’s health, well-being, and satisfaction as well as the overall system performance.

**Objective**
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

**Content**
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

**Literature**
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brochures, checklists, key articles etc. are uploaded in ILIAS

**376-1179-00L Applications of Cybernetics in Ergonomics**

**Abstract**

**Objective**

**Content**

**Literature**
- Further textbooks are introduced in the lecture
- Brochures, checklists, key articles etc. are uploaded in ILIAS

**Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1170 of 2416**
Abstract
Cybernetics systems have been studied and applied in various research fields, such as for applications in ergonomics. Topics discussed in this lecture (man-machine-interaction, performance in multi-modal interactions, quantification in gestalt principles for the use in product development, information processing) are deepened with exercises conducted at our labs.

Objective
To learn and practice cybernetics principles in interface designs and product development.

Content
- Fitt’s law applied in manipulation tasks
- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection
- Accommodation/vergence crosslink function
- Cross-link models in neurobiology- the ocular motor control system
- Human performance in optimization of production lines

Literature
Literature

Introductory Books:


Selected Journal Articles and Web Links:


VideoTact, ForeThought Development, LLC. http://my.execpc.com/?dwysocki/videotac.html

Prerequisites / notice

Target Group:
Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
Students of other departments, faculties, courses are also welcome
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

376-1353-00L Nanostructured Materials Safety

Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

Lecture notes
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies not assessed
Decision-making not assessed
Problem-solving not assessed
Project Management not assessed
Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed

376-1661-00L Ethics of Life Sciences and Biotechnology

Number of participants limited to 100
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

### 376-1714-00L Biocompatible Materials

**Abstract**

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**

The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**

Handouts are deposited online (moodle).

**Literature**


(available online via ETH library)

Handouts and references therein.

### 376-1720-00L Application of MATLAB in the Human Movement

**Abstract**

Students will learn to import, process and graphically present experimental data using the MATLAB computing environment. Both the data and the methods of analysis will be typical for experiments in Human Movement Science (i.e. kinematics, kinetics and electromyography).

**Objective**

Students will acquire the ability to independently load, plot, and process kinematic, kinetic and electromyographical data using the MATLAB computing environment.

**Content**

Drawbacks of Excel; Possibilities in MATLAB: Import of several data formats; Plot of one and more signals; Removing of an offset and filtering of data based on self-written functions; Normalisation and parametrisation of data; Reliability; Interpolation, Differentiation and Integration in MATLAB.

**Literature**

During the lecture, several electronically available MATLAB introductions are indicated. Course-specific scripts will be provided by the lecturer.

**Prerequisites / notice**

A Laptop with MATLAB installed (v2009 or higher) and wireless internet access is mandatory. Two students can share a laptop if necessary. A MATLAB student version can be obtained at Stud-IDES for free.

### 376-1722-00L Spinal Cord Injury and Exercise

**Abstract**

Intensive discussion concerning complications of a spinal cord injury and their consequences on trainability and exercise performance of persons sitting in a wheelchair. Overview on the clinical application of exercise testing as well as on the implementation of sport scientific findings to optimise performance of individuals with spinal cord injury in rehabilitation and elite sports.

**Objective**

Knowledge of the pathophysiology and the concomitant complications of a spinal cord injury and the consequences for physical exercise and trainability during rehabilitation as well as in recreational and elite sport.

**Content**

The following issues will be discussed: Epidemiology and etiology of spinal cord injury; complications and consequences of spinal cord injury; trainability/exercise physiology and spinal cord injury; history and organisation of wheelchair sports; elite sport and spinal cord injury
### Literature

**General literature:**

- H.G. Koch, V. Geng
  Querschnittlähmung verständlich erklärt (Band 1 und Band 2)
  Selbstverlag Manfred-Sauer-Stiftung und Schweizer Paraplegiker-Vereinigung
  ISBN 978-3-00-069888-0 (Band 1) und 978-3-00-069889-7 (Band 2)

- G.A. Zäch, H. G. Koch
  Paraplegie - ganzheitliche Rehabilitation
  Karger-Verlag, 2006
  ISBN 3-8055-7980-2

- V. Goosey-Tolfrey
  Wheelchair sport: A complete guide for athletes, coaches and teachers
  Human Kinetics, 2010

- Y.C. Vanlandewijck, W.R. Thompson
  The Paralympic Athlete
  Wiley-Blackwell, 2011
  ISBN 978-1-4443-3404-3

- Liz Broad
  Sports Nutrition for Paralympic Athletes, Second Edition
  CRC Press 2019

- Y.C. Vanlandewijck, W.R. Thompson
  Training and Coaching the Paralympic Athlete
  ISBN 978-1-119-04433-8


### Prerequisites / notice

**Voraussetzung:** Vorlesung Anatomie/Physiologie besucht!

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td><strong>Subject-specific Competencies</strong></td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td><strong>Method-specific Competencies</strong></td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Negotiation</td>
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<td><strong>Personal Competencies</strong></td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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### 376-1723-00L Big Data Analysis in Biomedical Research

**Number of participants limited to 20.**

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<tr>
<th>W</th>
<th>4 credits</th>
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<tr>
<td>E. Araldi, M. Ristow</td>
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</table>

**Abstract**

Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data.

**Objective**

This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and machine learning approaches. For the final assessment, students will conduct an independent data analysis project based on a biomedical problem of their choosing and using publicly available population-based biomedical datasets.

**Content**

While learning the programming skills needed to manipulate and visualize the data, participants will learn the statistical and modeling approaches for big data analysis. The course will cover:

- Basis of Python programming and UNIX;
- High performance computing;
- Manipulation and cleaning of large datasets with Pandas;
- Visualization tools (Matplotlib, Seaborn);
- Machine learning and numerical libraries (SciPy, NumPy, Statsmodels, Scikit-Learn);
- Statistical analysis and modeling of big data, and applications to biomedical datasets (statistical learning, distributions, linear and logistic regressions, principal component analysis, clustering, classification, time series analysis, tree-based methods, predictive models).

**Prerequisites / notice**

Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.

### 376-1974-00L Colloquium in Biomechanics

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**Abstract**

Current topics in biomechanics presented by speakers from academia and industry.

**Objective**

Getting insight into actual areas and problems of biomechanics.

### 376-1985-00L Trauma Biomechanics

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<tr>
<th>W</th>
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<tr>
<td>K.-U. Schmitt, M. H. Muser</td>
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</table>

**Abstract**

Trauma biomechanics, analysis of injury mechanisms and the role of mechanical forces in tissue response.
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

Introduction to the basic principles of trauma biomechanics.

This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

Handouts will be made available.

The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy assessed.

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

The course introduces basic concepts of the interaction between nutrition and exercise performance. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

The objective of this course is to highlight the intimate links between human physiology and product sensory and nutritional functions. To optimize these functions, an understanding of the physiological functions that interact and encode the actions of those product structures must be well understood.

Therefore the objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures.

The students will be exposed to this interplay all along the GI tract, including taste, aroma and texture perception, swallowing mechanics and gastro intestinal digestion with an engineering or physical sciences angle.

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<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>Writing of a review paper of scientific quality on a topic in the domain of Human Health, Nutrition and Environment based on critical evaluation of scientific literature.</td>
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</table>
| Objective  | - Acquisition of knowledge in the field of the review paper  
- Assessment of original literature as well as synthesis and analysis of the findings  
- Practising of academic writing in English  
- Giving an oral presentation with discussion on the topic of the review paper |
| Content    | Topics are offered in the domains of the major "Human Health, Nutrition and Environment" covering "Public Health", "Infectious Diseases", "Nutrition and Health" and "Environment and Health". |
| Lecture notes | Guidelines will be handed out in the beginning. |
| Literature | Literature will be identified based on the topic chosen. |

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<tbody>
<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
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<tr>
<td>Abstract</td>
<td>The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.</td>
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<tr>
<td>Objective</td>
<td>The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware of how epidemiological facts are used in prevention, practice and politics.</td>
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<tr>
<td>Content</td>
<td>The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.</td>
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<tr>
<td>752-6151-00L</td>
<td>Public Health Concepts</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Heusser</td>
</tr>
<tr>
<td>Abstract</td>
<td>The module &quot;public health concepts&quot; offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.</td>
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</table>
| Objective  | At the end of this module students are able:  
- to interpret the results of epidemiological studies  
- to critically assess scientific literature  
- to know the definition, dimensions and determinants of health  
- to plan public health interventions and health promotion projects  
- to draw a bridge from evidence to policies and politics |
| Content    | Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition). |
| Lecture notes | Handouts are provided to students in the classroom. |

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<tbody>
<tr>
<td>752-6403-00L</td>
<td>Nutrition and Performance</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>S. Mettler, M. B. Zimmermann</td>
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<tr>
<td>Abstract</td>
<td>The course introduces basic concepts of the interaction between nutrition and exercise performance.</td>
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<tr>
<td>Objective</td>
<td>To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.</td>
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<tr>
<td>Content</td>
<td>The course will cover elementary aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise. Although this is a scientific course, it is a goal of the course to translate basic sports nutrition science into practical sports nutrition examples.</td>
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<tr>
<td>Literature</td>
<td>Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.</td>
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<tr>
<td>376-0300-00L</td>
<td>Translational Science for Health and Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfrum</td>
</tr>
<tr>
<td>Abstract</td>
<td>Translational Science for Health and Medicine</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1176 of 2416
What is translational science and what is it not?

How to identify need?
- Disease concepts and consequences for research
- Basics about incidence, prevalence etc., and orphan indications

How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources

How to measure success?
- Outcome variables
- Improving the translational process

Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.
Elective Courses II

Module: Infectious Diseases

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<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
<tr>
<td>701-1471-00L</td>
<td>Ecological Parasitology n</td>
<td>W</td>
<td>3</td>
<td>1V+1P</td>
<td>F. A. A. Feijen, J. Jokela, C. Vorburger</td>
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</table>

Abstract

The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

Objective

At the end of this module students are able:
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

Content

Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PH nutrition).

Lecture notes

Handouts are provided to students in the classroom.

Literature

Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice

Immunology I and II recommended but not compulsory

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<tr>
<th>Number</th>
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<td>1V+1P</td>
<td>F. A. A. Feijen, J. Jokela, C. Vorburger</td>
</tr>
</tbody>
</table>

Abstract

This course provides a detailed understanding of
- development of T and B cells
- the dynamics of a immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective

Obtain a detailed understanding of
- the development, activation, and differentiation of different types of T and their effectormechanisms during immune responses,
- recognition of pathogenic microorganisms by the host cells and molecular events thereafter,
- events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
- Optimization of B cell responses by intelligent design of new vaccines

Content

- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature

Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites / notice

Immunology I and II recommended but not compulsory
Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria).

Prerequisites / notice
The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

701-1703-00L Evolutionary Medicine for Infectious Diseases
W 3 credits 2G A. Hall

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
Schmid Hempel 2011 Evolutionary Parasitology
Stearns & Medzhitov 2016 Evolutionary Medicine

752-4009-00L Molecular Biology of Foodborne Pathogens
W 3 credits 2V M. Loessner, M. Schmelcher, M. Schuppler, E. Wetter Slack

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

752-2122-00L Food and Consumer Behaviour
W 2 credits 2V M. Siegrist, F. Michel

Number  Title Type ECTS Hours Lecturers
752-2122-00L Food and Consumer Behaviour W 2 credits 2V M. Siegrist, F. Michel

Abstract
This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products.

Objective
The course provides an overview about the following topics: Factors influencing consumer's food choice, food and health, attitudes towards new foods and food technologies, labeling and food policy issues

752-5103-00L Functional Microorganisms in Foods
W 3 credits 2G C. Lacroix, A. Geinaert, A. Greppi

Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food
and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will
contribute to different topics:

- **Probiotics and Prebiotics:** human gut microbiota, functional foods and microbial-based products for gastrointestinal health and
  functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- **Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety:** antifungal cultures; bacteriocin-producing cultures
  (bacteriocins); long path from research to industry in the development of new protective cultures.

- **Legal and protection issues related to functional foods**

- **Industrial biotechnology of flavor and taste development**

- **Safety of food cultures and probiotics**

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and
claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

**Module: Environment and Health**

<table>
<thead>
<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
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<td>W</td>
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**Number**

**Title**

**Type**

**ECTS**

**Hours**

**Lecturers**

**Prerequisites / notice**

**Fostered competencies**

**Literature**

**Prerequisites / notice**

**Abstract**

**Objective**

**Lecture notes**

**Subject-specific Competencies**

**Method-specific Competencies**

**Social Competencies**

**Concepts and Theories**

**Techniques and Technologies**

**Analytical Competencies**

**Decision-making**

**Problem-solving**

**Project Management**

**Communication**

**Cooperation and Teamwork**

**assessed**

**not assessed**

**Major in Medical Technology**

**Compulsory Courses**

<table>
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<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfrum</td>
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**Number**

**Title**

**Type**

**ECTS**

**Hours**

**Lecturers**

**Abstract**

**Objective**

**Content**

**assessed**

**not assessed**

**Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.**

After completing this course, students will be able to understand:

- **Principles of translational science** (including project planning, ethics application, basics of resource management and interdisciplinary
  communication)

What is translational science and what is it not?

- **Disease concepts and consequences for research**

- **Basics about incidence, prevalence etc., and orphan indications**

- **How to choose the appropriate research type and methodology**

- **Ethical considerations including ethics application**

- **Pros and cons of different types of research**

- **How to measure success?**

- **Outcome variables**

- **Improving the translational process**

- **Challenges of communication?**

- **How independent is translational science?**

- **Academic boundary conditions vs. industrial influences**

Positive and negative examples will be illustrated by distinguished guest speakers.
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**

Students will learn how to:
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Explain advantages and limitations of different imaging methods in relation to medical diagnostic applications
- Identify system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Explain advantages and limitations of different imaging methods in relation to medical diagnostic applications

**Content**

Main topics of the course include:
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

**Literature**

- Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011
- Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

**Lecture notes**

Lecture notes and handouts

**Data:** 01.11.2022 12:41

**Autumn Semester 2022**
Biomedical Engineering

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content
History of BME and the role of biomedical engineers. Ethical issues related to BME. Biomedical sensors both wearable and also biochemical sensors. Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices. Bioinformatics: genomic and proteomic tools, databases and basic calculations. Equations describing basic reactions and enzyme kinetics. Medical optics: Optical components and systems used in hospitals. Basic concepts of tissue engineering and organ printing. Biomaterials and their medical applications. Function of the heart and the circulatory system. Transport and exchange of substances in the human body, compartment modeling. The respiratory system. Bioimaging. Orthopedic biomechanics. Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Method-specific Competencies</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<tr>
<td>Personal Competencies</td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-direction and Self-management</td>
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</table>

Bioelectronics and Biosensors

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectric signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field
Content

Lecture topics:

1. Introduction

Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics.
In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

227-0447-00L Image Analysis and Computer Vision W 6 credits 3V+1U E. Konukoglu, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.
The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer.
The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.
The course language is English.

227-0939-00L Cell Biophysics W 6 credits 4G T. Zambelli

Abstract
Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life's mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

Literature


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Notions of vectors in 2D and 3D are beneficial.

Abstract

The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Content

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes

Available online

Winter Semester 2022

227-0965-00L | Micro and Nano-Tomography of Biological Tissues

W | 4 credits | 3G | M. Stampanoni, F. Marone Welford

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1184 of 2416
Literature
Will be indicated during the lecture.

227-0969-00L Methods & Models for fMRI Data Analysis W 6 credits 4V K. Stephan

Abstract
This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective
To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

327-0505-00L Surfaces, Interfaces and their Applications I W 3 credits 2V+1U N. Spencer, M. P. Heuberger, L. Isa

Abstract
After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

Objective
To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

Content
Introduction to Surface Science
Physical Structure of Surfaces
Surface Forces (static and dynamic)
Adsorbates on Surfaces
Surface Thermodynamics and Kinetics
The Solid-Liquid Interface
Electron Spectroscopy
Vibrational Spectroscopy on Surfaces
Scanning Probe Microscopy
Introduction to Tribology
Introduction to Corrosion Science

Lecture notes
Script Download:
https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Literature
Script Download:
https://moodle-app2.let.ethz.ch/course/view.php?id=17455

Prerequisites / notice
Chemistry;
General undergraduate chemistry
including basic chemical kinetics and thermodynamics

Physics:
General undergraduate physics
including basic theory of diffraction and basic knowledge of crystal structures

Fostered competencies
Subject-specific Competencies
Concepts and Theories
assessed
Techniques and Technologies
assessed

Method-specific Competencies
Analytical Competencies
assessed
Decision-making
assessed
Problem-solving
assessed

Personal Competencies
Creative Thinking
assessed
Critical Thinking
assessed


Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques for imaging and analysis by SEM.
Lecture notes will be distributed.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.

<table>
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<th>Code</th>
<th>Title</th>
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<tr>
<td>327-2126-00L</td>
<td>Microscopy Training TEM I - Introduction to TEM</td>
<td>W 2</td>
<td>3P</td>
<td>P. Zeng, E. J. Barthazy Meier,</td>
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<td>A. G. Bittermann, F. Gramm, A. Sologubenko</td>
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</table>

Objective
Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

Content
Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

<table>
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<td>363-0790-00L</td>
<td>Technology Entrepreneurship</td>
<td>W 2</td>
<td>2V</td>
<td>F. Hacklin</td>
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Abstract
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Objective
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1186 of 2416
Developing Digital Biomarkers

Objective

The course has four core learning objectives. Students should:

1. Understand the anatomy of digital biomarkers
2. Understand the potential and applications of digital biomarkers
3. Be able to critically reflect and assess existing digital biomarkers
4. Be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1. Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2. Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3. Methodology: In the last decade, neural networks (also known as "deep learning") have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4. Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

Materials and Mechanics in Medicine

Abstract

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective

Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content

Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes

Introduction to Biomedical Engineering, 3rd Edition 2011.

Literature

Autor: John Endler, Joseph Bronzino, ISBN 9780123749796

Academic Press

Multiscale Bone Biomechanics

Number of participants limited to 30

Abstract

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

Objective

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Content

1. Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2. Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3. Methodology: In the last decade, neural networks (also known as "deep learning") have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4. Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.

Materials and Mechanics in Medicine

Abstract

Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Objective

Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content

Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes

Introduction to Biomedical Engineering, 3rd Edition 2011.

Literature

Autor: John Endler, Joseph Bronzino, ISBN 9780123749796

Academic Press
The seminar provides state-of-the-art insight to the biomechanical function of bone from molecules, to cells, tissue and up to the organ. Multiscale imaging and simulation allows linking different levels of hierarchy, where systems biology helps understanding the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

Objective

The learning objectives include:

1. advanced knowledge of the state-of-the-art in multiscale bone biomechanics;
2. basic understanding of the biological principles governing bone in health, disease and treatment from molecules, to cells, tissue and up to the organ;
3. good understanding of the prevalent biomechanical testing and imaging techniques on the various levels of bone hierarchy;
4. practical implementation of state-of-the-art multiscale simulation techniques;
5. improved programming skills through the use of python.
6. hands on experience in designing solutions for clinical and industrial problems;
7. encouragement of critical thinking and creating an environment for independent and self-directed studying.

Content

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis. To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUES). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUES: Tiny, Open-with-Restrictions Courses focused on Quality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A). Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

Number of Participants limited to 16

Abstract

The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimulus. In this course, the students will acquire insights into the molecular aspects of muscle biology and exercise, in addition to gaining hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

Objective

The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Content

The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students- each one will focus on one of the following research topics:

Topic 1: Molecular pathways that control muscle stem cell self-renewal and differentiation
Topic 2: Genome engineering to correct genetic mutations that cause muscle diseases
Topic 3: Muscle fiber composition, force production and insulin sensitivity
Topic 4: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group's research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

i. Group 1: tissue culture, isolation of muscle stem cells via FACS, differentiation of muscle stem cell into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, Immunofluorescence.
ii. Group 2: tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers. Immunofluorescence and muscle PCR.
iii. Group 3: ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, Immunofluorescence and western blot.
iv. Group 4: tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers. Western blot.

Prerequisites / notice

Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

376-0208-00L

Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects

W 3 credits
2G O. Bar-Nur, K. De Bock

Abstract

The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimulus. In this course, the students will acquire insights into the molecular aspects of muscle biology and exercise, in addition to gaining hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

Objective

The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

Content

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Topic 1: Molecular pathways that control muscle stem cell self-renewal and differentiation
Topic 2: Genome engineering to correct genetic mutations that cause muscle diseases
Topic 3: Muscle fiber composition, force production and insulin sensitivity
Topic 4: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session.

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Select practical methods that the proposed course will teach include:

i. Group 1: tissue culture, isolation of muscle stem cells via FACS, differentiation of muscle stem cell into muscle fibers, small molecules screens, quantitative analysis of muscle cell proliferation and fusion, Immunofluorescence.
ii. Group 2: tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers. Immunofluorescence and muscle PCR.
iii. Group 3: ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, Immunofluorescence and western blot.
iv. Group 4: tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers. Western blot.

Prerequisites / notice

376-0006-02L Laboratory Course in Molecular biology

376-0816-00L

Applied Human Research Project Management

W 4 credits
3G C. Lustenberger, M. Altermatt

Abstract

This course equips the students with several key principles such as good clinical practice, ethical study requirements, reproducible data management and effective oral, graphical, and written communication to design and manage good quality, ethically sound human research studies and represents a 101-toolkit of transferable research management skills/digital tools.
Objective: The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Create/select well-founded research hypotheses and study designs for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects
- Integrate principles of effective communication in speaking, writing and graphical illustrations of future research idea/output

Content: The course will cover the following topics:

- Introduction to different study designs and ethical requirements thereof in Switzerland
- Introduction to literature search and searching platforms
- How to collect and sort publications/keep up to date on research topic
- Inputs on critically evaluating papers
- How to pre-define study requirements to “future-proof” the research (hypothesis, sample size definition, pre-registration)
- Correct conduction of fundamental human research procedures (e.g., screening, consent process, CRF) and identification/prevention of deviations and emergencies (e.g., SAE/AE, protocol violation, research misconduct)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metatiles)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Objective</th>
<th>Abstract</th>
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<tbody>
<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>4</td>
<td>2V</td>
<td>C. Vogel, further lecturers</td>
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</tbody>
</table>

Objective: Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

Content: Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes: All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

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<tr>
<td>376-1151-00L</td>
<td>Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging</td>
<td>3</td>
<td>2V</td>
<td>C. Ewald</td>
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</table>

Objective: The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention.

Learning objectives include:
1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
2. Analyse/compare current molecular/genetic strategies that address these aging problems.
3. Analyse/compare case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.

Prerequisites: No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.

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<th>Objective</th>
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<tr>
<td>376-1176-00L</td>
<td>Wearable and Mobile Technologies of the Future - Focus on Sports and Health</td>
<td>4</td>
<td>3G</td>
<td>C. Menon, C. Ahmadizadeh, M. Elgendi</td>
</tr>
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</table>

Objective 1: Acquire knowledge about the latest technological advancements in wearable and unobtrusive technologies for sport and health.

Objective 2: Acquire skills to design novel non-invasive technologies for sport and health.
The course consists of three modules.

Module 1: The Heart.
This module focuses on the latest technologies for monitoring the cardiac cycle and blood pressure. The module starts by succinctly providing background information on cardiac physiology and then briefly introduces conventional technologies used in daily practice. This module subsequently focuses on the latest technologies (e.g., smartphone/camera-based methods, seismocardiography) and the latest data analysis techniques to monitor the cardiac cycle and blood pressure for assisting individuals in sport activities or monitoring their health conditions.

Module 2: The Mind.
This module investigates the latest advancements in wearable technologies for monitoring mental state, cognition and emotion and possibly assist individuals to improve their attention/cognition and to address related conditions (e.g., depression). The module initially provides a scientific background to the topic and then introduces the latest technological advancements in the field (e.g., in-ear electroencephalography, galvanic vestibular stimulation, textile-based breathing- and sweat sensing technologies). Students will be involved in a project to put into practice the knowledge and skills acquired during this module.

Module 3: Movement.
This module provides the needed scientific background to understand the principles that current technologies investigating movement rely on. The latest technological advancements to track parameters of gait and running, improve posture as well as to monitor overall body movement and provide feedback on motion during sport, rehabilitation or at work will be investigated. The focus will be on wearable-related (e.g., textile-based) technologies. In the last part of this module, representatives from industry and/or world-renowned scientists will present their views on the latest trends in academia and industry (e.g., self-powering wearable solutions).

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<th>Course Title</th>
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<th>Professor(s)</th>
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<tr>
<td>376-1177-00L</td>
<td>Human Factors I</td>
<td>3</td>
<td>2022</td>
<td>M. Menozzi Jäckli, R. Huang, M. Siegrist</td>
</tr>
<tr>
<td>376-1179-00L</td>
<td>Applications of Cybernetics in Ergonomics</td>
<td>1</td>
<td>2022</td>
<td>M. Menozzi Jäckli, Y.-Y. Hedinger Huang, R. Huang</td>
</tr>
<tr>
<td>376-1219-00L</td>
<td>Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions</td>
<td>3</td>
<td>2022</td>
<td>R. Rienner, O. Lambency</td>
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</tbody>
</table>

Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Content

- Introduction, problem definition, overview
- Rehabilitation of visual function
  - Anatomy and physiology of the visual sense
  - Technical aids (glasses, sensor substitution)
  - Retina and cortex implants
  - Rehabilitation of hearing function
  - Anatomy and physiology of the auditory sense
  - Hearing aids
  - Cochlea Implants
  - Rehabilitation and use of kinesthetic and tactile function
  - Tactile/haptic displays for motion therapy (incl. electrical stimulation)
  - Role of displays in motor learning
- Rehabilitation of vestibular function
  - Anatomy and physiology of the vestibular sense
  - Rehabilitation strategies and devices (e.g. BrainPort)
- Rehabilitation of vegetative Functions
  - Cardiac Pacemaker
  - Phrenic stimulation, artificial breathing aids
  - Bladder stimulation, artificial sphincter
- Brain stimulation and recording
  - Deep brain stimulation for patients with Parkinson, epilepsy, depression
  - Brain-Computer Interfaces

Introduction, problem definition, overview

Overview of Rehabilitation of functional systems

Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
- Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
- Rehabilitation and use of kinesthetic and tactile function
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning

Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)

Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Prerequisites / notice

Target Group:
Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

Literature

Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice

Target Group:
Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

376-1351-00L Micro/Nanotechnology and Microfluidics for W 2 credits 2V E. Delamarche

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1191 of 2416
### Biomedical Applications

**Abstract**

This course is an introduction to techniques in micro/nanotechnology and to microfluidics. It reviews how many familiar devices are built and can be used for research and biomedical applications. Transistors for DNA sequencing, beamers for patterning proteins, hard-disk technology for biosensing and microfluidics for point-of-care diagnostics are just a few examples of the covered topics.

**Objective**

The main objective of the course is to introduce micro/nanotechnology and microfluidics to students having any technical background. The course is multi-disciplinary and covers a broad range of techniques. For each lecture, a brief historical perspective is given to illustrate by whom and how the techniques were invented.

The course should familiarize the students with the techniques used in micro/nanotechnology, cleanroom microfabrication, and show them how micro/nanotechnology pervades throughout life sciences. Microfluidics will be emphasized due to their increasing importance in research and for medical applications.

The second objective is to have life sciences students less intimidated by micro/nanotechnology and make them able to link instruments and techniques to specific problems that they might have in their projects/studies. This will also help students getting access to the ETHZ/IBM Nanotech Center infrastructure if needed.

**Content**

Mostly formal lectures (2 × 45 min), with few specific guest lectures on topics of particular relevance. For example, an introduction to cleanroom and micro/nanotechnology instruments and 3D printing will be provided. Last 3 weeks would be dedicated to the presentation and evaluation of projects by students (2 to 3 students per team). For this, about 12 recent technologies are listed and each team picks a technology and makes a short report and presentation describing how it works, its strengths and weaknesses, and describes what problem it solves.

In terms of technical content, the lectures will cover:
- an overview of the microelectronic industry, Moore’s law, field-effect transistors, next-generation DNA sequencing
- liquid crystal displays, organic light emitting diodes, electrophoretic displays, micromirrors and beams, photopatterning of proteins and cells, optogenetics, and flexible displays and electronics
- hard disk drives and the giant magnetoresistance effect, magnetic nanoparticles, photonics, magnetic sensing and optical biosensing
- cleanroom techniques and instruments, from design to microfabrication of simple devices and microfluidics, examples of DNA microarrays
- the principles of microfluidics, microfluidic functions and fabrication, from microfluidics for research to point-of-care diagnostics, and the (infamous) history of Theranos, as well as some discussions on diagnostics for COVID, R0, and (im)precision of diagnostic devices and why it matters
- specifically for the 2022 course, Yuksel Temiz, a master of Arduino programming and do-it-yourself electronics, will kick-off the course and will show how to make 20S electronic components that are synergistic to microfluidic devices and that can be controlled using a smartphone
- the 2022 course will also include 3D printing for the fast prototyping of microfluidic devices

**376-1353-00L Nanostructured Materials Safety**

**Abstract**  
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

**Objective**  
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

**Lecture notes**  
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

**Prerequisites / notice**  
A course “Introduction to Toxicology”

**Fostered competencies**  
Subject-specific Competencies: Concepts and Theories assessed  
Techniques and Technologies assessed

**Method-specific Competencies**  
Analytical Competencies not assessed

**Social Competencies**  
Communication not assessed

**Prerequisites / notice**  
Course “Introduction to Toxicology”

**376-1504-00L Physical Human Robot Interaction (pHRI)**

**Abstract**  
This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

**Objective**  
The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de- sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1. Identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2. Compare and select mechatronic components that optimally fulfill the defined design requirements;
3. Derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4. Design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5. Characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6. Investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

**Content**

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

**Lecture notes**  
Will be distributed on Moodle before the lectures.

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**Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1192 of 2416**


Introduction to the basic principles of trauma biomechanics.


The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics about which will be relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

376-1714-00L

**Biocompatible Materials**

**W** 4 credits 3V K. Maniura, M. Rottmar, M. Zenobi-Wong

**Abstract**

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

**Objective**

The course covers the following topics:

1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. Understanding of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

**Content**

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

**Lecture notes**

Handouts are deposited online (moodle).

**Literature**


(available online via ETH library)

376-1723-00L

**Big Data Analysis in Biomedical Research**

**W** 4 credits 2V+2U E. Araldi, M. Ristow

**Abstract**

Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data

**Objective**

This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and machine learning approaches. In the final assessment, students will conduct an independent data analysis project based on a biomedical problem of their choosing and using publicly available population-based biomedical datasets.

**Content**

While learning the programming skills needed to manipulate and visualize the data, participants will learn the statistical and modeling approaches for big data analysis. The course will cover:

- Basis of Python programming and UNIX
- High performance computing
- Manipulation and cleaning of large datasets with Pandas
- Visualization tools (Matplotlib, Seaborn)
- Machine learning and numerical libraries (SciPy, NumPy, Statsmodels, Scikit-Learn)
- Statistical analysis and modeling of big data, and applications to biomedical datasets (statistical learning, distributions, linear and logistic regressions, principal component analysis, clustering, classification, time series analysis, tree-based methods, predictive models).

**Prerequisites / notice**

Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor's level.

376-1985-00L

**Trauma Biomechanics**

**W** 4 credits 2V+1U K.-U. Schmitt, M. H. Muser

**Abstract**

Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

**Objective**

Introduction to the basic principles of trauma biomechanics.

**Content**

This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

**Lecture notes**

Handouts will be made available.

**Literature**

After this course students:

- got introduced to Generalised Linear Models
- revised Linear Models
- got introduced to Linear Mixed-Effects Models and Generalised Additive Models
- can interpret the results of such an analysis and draw valid "biological" conclusions
- can perform the data analysis using the statistical software R

Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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</table>

Abstract

Current topics in biomechanics presented by speakers from academia and industry.

Objective

Getting insight into actual areas and problems of biomechanics.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Type</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
</table>

**Applied Biostatistics**

This course covers the main methods used in Biostatistics. It starts by revising Linear Models (Regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

**Objective**

After this course students:

- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

**Abstract**

After this course students:

- revised Linear Models
- got introduced to Generalised Linear Models
- got introduced to Linear Mixed-Effects Models
- got introduced to Generalised Additive Models
- are able to select among these methods to solve an applied problem in Biostatistics
- can perform the data analysis using the statistical software R
- can interpret the results of such an analysis and draw valid "biological" conclusions

**Content**

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both: part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation.

Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

**Prerequisites / notice**

The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommend to view the online R course "etutoR".

**Physics in Medical Research: From Atoms to Cells**

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

**Objective**

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increse of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.
<table>
<thead>
<tr>
<th>Module Code</th>
<th>Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
</tr>
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<tbody>
<tr>
<td>529-0041-00L</td>
<td>Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics</td>
<td>W</td>
<td>6</td>
<td>3G</td>
</tr>
<tr>
<td>R. Zenobi, B. Hatendorf, P. Sinués Martinez-Lozano</td>
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</table>

**Abstract**
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

**Objective**
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

**Content**
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

**Lecture notes**
Lecture notes will be made available online.

**Literature**
Information about relevant literature will be available in the lecture & in the lecture notes.

**Prerequisites / notice**
Exercises are an integral part of the lecture.

**Fostered competencies**

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<tr>
<th>Competency Area</th>
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<th>Assessed</th>
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<tbody>
<tr>
<td>Subject-specific Competencies</td>
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<tbody>
<tr>
<td>535-0423-00L</td>
<td>Drug Delivery and Drug Targeting</td>
<td>W</td>
<td>2</td>
<td>1.5V</td>
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<tr>
<td>J.-C. Leroux</td>
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</table>

**Abstract**
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

**Objective**
The students dispose of an overview of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

**Content**
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

**Lecture notes**
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

**Literature**


Further references will be provided in the course.

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<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
</tr>
<tr>
<td>M. Kopf, A. Oxenius</td>
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</table>

**Abstract**
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.
Adaptability and Flexibility

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to

not assessed

U. Kutay

Communication

assessed

Not assessed

M. Fussenegger

Introduction and historical background

- Innate and adaptive immunity. Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature - Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies not assessed

Decision-making assessed

Media and Digital Technologies not assessed

Problem-solving assessed

Project Management not assessed

Social Competencies

Communication not assessed

Cooperation and Teamwork not assessed

Customer Orientation not assessed

Leadership and Responsibility not assessed

Self-presentation and Social Influence not assessed

Sensitivity to Diversity assessed

Negotiation not assessed

Personal Competencies

Adaptability and Flexibility not assessed

Creative Thinking not assessed

Critical Thinking assessed

Integrity and Work Ethics not assessed

Self-awareness and Self-reflection assessed

Self-direction and Self-management assessed

551-0319-00L Cellular Biochemistry (Part I)

W 3 credits 2V U. Kutay, G. Neurohr, M. Peter, I. Zemp

Abstract Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into intracellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry. The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

636-0108-00L Biological Engineering and Biotechnology

W 4 credits 3V M. Fussenegger

Abstract Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content


Lecture notes Handout during the course.

752-3105-00L Physiology Guided Food Structure and Process Design

W 3 credits 2V E. J. Windhab, M. Devezzeaux de Lavernge, B. von der Weid, T. Wooster
A "cook-and-look" approach to process design is no longer applicable in the current environmental, nutritional and competitive constraints. The modern R&D chemical/food engineer should have a clear focus on the desired structure that needs to be achieved to design a process line or a processing equipment, coupled with in depth knowledge of the processed materials.

The objective of this course is to highlight the intimate links between human physiology and product sensory and nutritional functions. To optimize these functions, an understanding of the physiological functions that interact and encode the actions of those product structures must be well understood.

Therefore the objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures.

The students will be exposed to this interplay all along the GI tract, including taste, aroma and texture perception, swallowing mechanics and gastrointestinal digestion with an engineering or physical sciences angle.

### Major in Molecular Health Sciences

#### Compulsory Courses

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-0300-00L</td>
<td>Translational Science for Health and Medicine</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>J. Goldhahn, C. Wolfrum</td>
</tr>
<tr>
<td>376-0302-01L</td>
<td>GCP Basic Course (Modules 1 and 2)</td>
<td>O</td>
<td>1</td>
<td>1G</td>
<td>G. Senti, C. Fila, R. Grossmann</td>
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</tbody>
</table>

**Abstract**

Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

**Objective**

After completing this course, students will be able to understand:

- Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)

**Content**

- What is translational science and what is it not?
- How to identify need?
  - Disease concepts and consequences for research
  - Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
  - Ethical considerations including ethics application
  - Pros and cons of different types of research
  - Coordination of complex approaches incl. timing and resources
- How to measure success?
  - Outcome variables
  - Improving the translational process
  - Challenges of communication?
- How independent is translational science?
  - Academic boundary conditions vs. industrial influences

Positive and negative examples will be illustrated by distinguished guest speakers.

### Elective Courses

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0939-00L</td>
<td>Cell Biophysics</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>T. Zambelli</td>
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</table>

**Abstract**

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life’s mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann’s law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Theory and corresponding exercises are merged together during the classes.

No lecture notes because the two proposed textbooks are more than exhaustive!

An extra hour (Mon 17.00 o'clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

!!!!! I am using OneNote. All lectures and exercises will be broadcast via ZOOM and correspondingly recorded (link in Moodle) !!!!!

Literature


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton’s and Coulomb’s laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

W 2 credits 3P

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Abstract

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1199 of 2416
**Objective**
- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

**Content**
During the course, students learn through lectures, demonstrations, and hands-on sessions how to set up and operate SEM instruments, including low-vacuum and low-voltage applications.

This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

**Lectures:**
- Introduction on Electron Microscopy and Instrumentation
- Electron Sources, Electron Lenses and Probe Formation
- Beam/Spectimen Interaction, Image Formation, Image Contrast and Imaging Modes
- Sample Preparation Techniques for EM
- X-ray Micro-analysis (Theory and Detection), Qualitative and Semi-quantitative EDX and Point Analysis, Linescan and Spectral Mapping

**Practicals:**
- Brief Description and Demonstration of the SEM Microscope
- Practice on Image Formation, Image Contrast (and Image Processing)
- Student Participation on Sample Preparation Techniques
- Scanning Electron Microscopy Lab Exercises: Setup and Operate the Instrument under Various Imaging Modalities
- Practice on Real-world Samples and Report Results

**Prerequisites / Notice**
No mandatory prerequisites.

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**327-2126-00L**
*Microscopy Training TEM I - Introduction to TEM*

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP0.html).

All applicants must additionally register on this form: (link will follow)
The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

**Abstract**
The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

**Objective**
Understanding of:
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to:
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

**Content**
Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

**Literature**

**Prerequisites / Notice**
No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

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**363-1163-00L**
*Developing Digital Biomarkers*

**Abstract**
The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world's aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:

- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as "deep learning") have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.
376-0208-00L  Molecular and Cellular Biology of Exercise and Muscle Regeneration - Practical Aspects

**Abstract**
The skeletal muscle biology field purposes to understand how muscles coordinate movement, regenerate following injury and adapt to exercise stimuli. It is especially challenging to gain hands-on experience in experimental techniques that are commonly used to research muscle regeneration and exercise.

**Objective**
The objective of this course is to introduce students into current research topics and outstanding questions in skeletal muscle biology. Also, the course will give students hands-on experience in respect to the tools needed to perform basic molecular biology research in the field of exercise and skeletal muscle biology. Students will learn how to translate a scientific question in muscle biology into a small scientific project. They will learn how to design an experiment and to analyze and critically interpret experimental data.

**Content**
The course will consist of 4 main research themes and the anticipated 16 students will be divided into 4 subgroups of 4 students each one will focus on one of the following research topics:

1. **Topic 1**: Molecular pathways that control muscle stem cell self-renewal and differentiation
2. **Topic 2**: Genome engineering to correct genetic mutations that cause muscle diseases
3. **Topic 3**: Muscle fiber composition, force production and insulin sensitivity
4. **Topic 4**: Amino acid sensitivity in skeletal muscle following exercise

The course will be organized into 7 sessions, each approx. 4 hours: the first 2 sessions will be theoretical and include an introductory lectures by the professors in addition to a journal club presentation by the students. This journal club aims to provide theoretical and scientific background that will be used to identify outstanding research questions. This will be followed by 4 practical sessions (hands-on experience) and 1 final evaluation session. For the journal club, each group of students will receive a peer-review article that is highly relevant to the respective group’s research topic. Each of the 4 groups will present and discuss the article in a journal club format to the rest of the participants the following week. During the four practical sessions, students will gain hands-on experiences and learn different lab techniques related to molecular biology of exercise and muscle regeneration. Each group will be presented with a research objective that is related to their topic, and perform in collaboration with teaching assistants a set of experiments that aim to address the research objective. At the final evaluation session, each group of students will present their results and identify follow-up research questions and hypothesis based on their experimental achievements.

Select practical methods that the proposed course will teach include:

- **i. Group 1**: tissue culture, isolation of muscle stem cells via FACS, differentiation of muscle stem cell into muscle fibers, small molecules screening, quantitative analysis of muscle cell proliferation and fusion. Immunofluorescence.
- **ii. Group 2**: tissue culture, differentiation of muscle stem cells into muscle fibers, guide RNA design and Crispr-Cas9 gene editing of genetic mutations that cause muscle diseases in muscle stem cells and fibers. Immunofluorescence and PCR.
- **iii. Group 3**: ex vivo assessment of muscle force characteristics, cryosectioning of muscle tissue, immunofluorescence and western blot.
- **iv. Group 4**: tissue culture of muscle stem cells, isolation of muscle stem cells and differentiation into muscle fibers, amino acid stimulation of muscle fibers. Western blot.

**Prerequisites / notice**
- Prerequisites: 376-0006-02L Laboratory Course in Molecular biology.

376-0303-00L  Colloquium in Translational Science (Autumn Semester)

**Abstract**
Current topics in translational medicine presented by speakers from academia and industry.

**Objective**
Getting insight into actual areas and problems of translational medicine.

**Content**
Timely and concise presentations of postgraduate students, post-docs, senior scientists, professors, as well as external guests from both academics and industry will present topics of their interest related to translational medicine.

**Prerequisites / notice**
- No compulsory prerequisites, but student should have basic knowledge about biomedical research.

376-1151-00L  Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging

**Number of participants limited to 30.**

**Abstract**
Recently, several start-up companies are aiming to translate basic molecular findings into new drugs/therapeutic interventions to slow aging or post-pone age-related diseases (e.g., Google founded Calico or Craig Venter's Human Longevity, Inc.). This course will teach students the basic skill sets to formulate their own ideas, design experiments to test them and explains the next steps to translate scientific background that will be used to identify outstanding research questions. Design experiments to test them and explains the next steps to translate.

**Objective**
The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention. Learning objectives include:

1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
2. Analyse/compare current molecular/genetic strategies that address these aging problems.
3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate.

**Content**
Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.

**Prerequisites / notice**
- No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.

376-1353-00L  Nanostructured Materials Safety

**Abstract**
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

**Objective**
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.

**Lecture notes**
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website.

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**Data:** 01.11.2022 12:41

**Autumn Semester 2022**

**Page 1202 of 2416**
**Prerequisites / notice**

Subject-specific Competencies: Concepts and Theories, Techniques and Technologies - assessed

Method-specific Competencies: Analytical Competencies - not assessed

Decision-making - not assessed

Problem-solving - not assessed

Project Management - not assessed

Social Competencies: Communication - not assessed

Cooperation and Teamwork - not assessed

**Abstract**
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

**Objective**
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

**Prerequisites / notice**
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

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**376-1622-00L**

**Practical Methods in Tissue Engineering**

*W* 5 credits 4P M. Zenobi-Wong, S. J. Ferguson, S. Grad, S. Schürle-Finke

**Number of participants limited to 12**

**Abstract**
The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

**Objective**
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

**Prerequisites / notice**
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

**376-1661-00L**

**Ethics of Life Sciences and Biotechnology**

*W* 3 credits 2V A. Blasimme, E. Vayena

**Number of participants limited to 100**

**Abstract**
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and practice how to use such resources to address concrete ethical issues in health sciences.

**Objective**
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

**Content**
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

**376-1723-00L**

**Big Data Analysis in Biomedical Research**

*W* 4 credits 2V+2U E. Araldi, M. Ristow

**Number of participants limited to 20**

**Abstract**
Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data.

**Objective**
This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and machine learning approaches. For the final assessment, students will conduct an independent data analysis project based on a biomedical problem of their choosing and using publicly available population-based biomedical datasets.

**Content**
While learning the programming skills needed to manipulate and visualize the data, participants will learn the statistical and modeling approaches for big data analysis. The course will cover:

- Basis of Python programming and UNIX;
- High performance computing;
- Manipulation and cleaning of large datasets with Pandas;
- Visualization tools (Matplotlib, Seaborn);
- Machine learning and numerical libraries (SciPy, NumPy, Statsmodels, Scikit-Learn);
- Statistical analysis and modeling of big data, and applications to biomedical datasets (statistical learning, distributions, linear and logistic regressions, principal component analysis, clustering, classification, time series analysis, tree-based methods, predictive models).

**Prerequisites / notice**
Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.

**529-0041-00L**

**Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics**

*W* 6 credits 3G R. Zenobi, E. Blattert, S. Sinués Martinez-Lozano

**Abstract**
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

**Objective**
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

**Content**
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods, Mass spectrometry imaging.

**Lecture notes**
Lecture notes will be made available online.

**Literature**
Information about relevant literature will be available in the lecture & in the lecture notes.
Exercises are an integral part of the lecture.

Prerequisites:
529-0051-00 "Analytische Chemie I (3. Semester)"
529-0058-00 "Analytische Chemie II (4. Semester)"
(or equivalent)

Exercises are an integral part of the lecture.

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Productivity and Time Management: not assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

Abstract
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of a immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective
- Obtain a detailed understanding of
  - the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses,
  - recognition of pathogenic microorganisms by the host cells and molecular events thereafter.
  - events and signals for maturation of naive B cells to antibody producing plasma cells and memory B cells.
  - Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifyeditingon=1

Prerequisites
Immunology I and II recommended but not compulsory

Abstract
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Objective
This course focuses on the concepts of classical and modern genetics and genomics.

Content
- The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

Lecture notes
Scripts and additional material will be provided during the semester.

Abstract
Introduction into structural and functional aspects of the immune system.

Objective
Basic knowledge of the mechanisms and the regulation of an immune response.
Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at “Lernmaterialien”

Literature
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a “Sessionsprüfung”. All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies not assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity assessed

Personal Competencies
- Adaptability and Flexibility not assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management assessed

Abstract
The course is a literature seminar or “journal club”. Each Friday a student, or a member of the Suter Lab in the Institute of Molecular Health Sciences, will present a paper from the recent literature.

Objective
The course introduces you to recent developments in the fields of cellular and molecular neurobiology. It also supports you to develop your skills in critically reading the scientific literature. You should be able to grasp what the authors wanted to learn i.e. their goals, why the authors chose the experimental approach they used, the strengths and weaknesses of the experiments and the data presented, and how the work fits into the wider literature in the field. You will present one paper yourself, which provides you with practice in public speaking.

Content
You will present one paper yourself. Give an introduction to the field of the paper, then show and comment on the main results (all the papers we present are available online, so you can show original figures with a beamer). Finish with a summary of the main points and a discussion of their significance.

You are expected to take part in the discussion and to ask questions. To prepare for this you should read all the papers beforehand (they will be announced a week in advance of the presentation).

Lecture notes
Presentations will be made available after the seminars.

Prerequisites / notice
You must attend at least 80% of the journal clubs, and give a presentation of your own. At the end of the semester there will be a 30 minute oral exam on the material presented during the semester. The grade will be based on the exam (45%), your presentation (45%), and a contribution based on your active participation in discussion of other presentations (10%).

551-0571-00L
From DNA to Diversity (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO336

Mind the enrolment deadlines at UZH:

Abstract
The evolution of the various body-plans is investigated by means of comparison of developmentally essential control genes of molecularly analysed model organisms.
Objective
By the end of this module, each student should be able to
- recognize the universal principles underlying the development of different animal body plans.
- explain how the genes encoding the molecular toolkit have evolved to create animal diversity.
- relate changes in gene structure or function to evolutionary changes in animal development.
Key skills:
- By the end of this module, each student should be able to
- present and discuss a relevant evolutionary topic in an oral presentation
- select and integrate key concepts in animal evolution from primary literature
- participate in discussions on topics presented by others

551-1153-00L Systems Biology of Metabolism

W 4 credits 2V U. Sauer, N. Zamboni, M. Zampieri
Number of participants limited to 15.

Abstract
Starting from contemporary biological problems related to metabolism, the course focuses on systems biological approaches to address them. In a problem-oriented, this-is-how-it-is-done manner, we thereby teach modern methods and concepts.

Objective
Develop a deeper understanding of how relevant biological problems can be solved, thereby providing advanced insights to key experimental and computational methods in systems biology.

Content
The course will be given as a mixture of lectures, studies of original research and guided discussions that focus on current research topics. For each particular problem studied, we will work out how the various methods work and what their capabilities/limits are. The problem areas range from microbial metabolism to cancer cell metabolism and from metabolic networks to regulation networks in populations and single cells. Key methods to be covered are various modeling approaches, metabolic flux analyses, metabolomics and other omics.

Lecture notes
Script and original publications will be supplied during the course.

Prerequisites / notice

551-1171-00L Immunology: From Milestones to Current Topics

W 4 credits 2S B. Ludewig, N. Pikor, L. Tortola
V. Korkhov, J. Kiesielow, A. Oxenius, University lecturers

Abstract
Milestones in Immunology: on old concepts and modern experiments

Objective
The course will cover the current grand topics in immunology: B cells, innate immunity, antigen presentation, tumor immunity, T cells, myeloid cells and stromal cells. For each topic two or four hours will be allocated. Historical milestone papers will be presented by the tutor/lecturer providing an overview on the development of the theoretical framework and critical technological advances. The students will read the historical milestone papers and contribute to the discussion. In the second part of the lecture, students will present recent high impact research papers that have emerged from the landmark achievements of the previously discussed milestone concepts.

Content
Milestones and current topics of innate immunity, antigen presentatino, B cells, thymus and T cells, cytotoxic T cells, NK cells, stromal cells, CNS immunity and tumor immunology.

Lecture notes
Original and review articles will be distributed by the respective lecturer.

Literature
Literatorunterlagen werden vor Beginn des Kurses auf folgender website zugänglich sein: https://moodle-app2.let.ethz.ch/course/view.php?id=15568

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies

Social Competencies
Communication
Self-presentation and Social Influence

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

551-1303-00L Cellular Biochemistry of Health and Disease

W 4 credits 2S V. Korkhov, T. Ishikawa, M. Jagannathan, R. Kroschewski, G. Neurohr, M. Peter, A. E. Smith, B. Snijder, K. Weis
Number of participants limited to 20.

Abstract
During this Masters level seminar style course, students will explore current research topics in cellular biochemistry focused on the structure, function and regulation of selected cell components, and the consequences of dysregulation for pathologies.

Objective
Students will work with experts toward a critical analysis of cutting-edge research in the domain of cellular biochemistry, with emphasis on normal cellular processes and the consequences of their dysregulation. At the end of the course, students will be able to introduce, present, evaluate, critically discuss and write about recent scientific articles in the research area of cellular biochemistry.

Content
Guided by an expert in the field, students will engage in classical round-table style discussions of current literature with occasional frontal presentations. Students will alternate as discussion leaders throughout the semester, with the student leader responsible to briefly summarize key general knowledge and context of the assigned primary research paper. Together with the faculty expert, all students will participate in discussion of the primary paper, including the foundation of the biological question, specific questions addressed, key methods, key results, remaining gaps and research implications.

Literature
The literature will be provided during the course

Prerequisites / notice

563-0017-00L Computational Biology

W 6 credits 3G+2A T. Vaughan, C. Magnus, T. Stadler

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
* stochastic models in molecular evolution
* phylogenetic & phylodynamic inference
* maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
* epidemiology
* pathogen evolution
* macroevolution of species
Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of systems biology, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture slides will be available on moodle.

Literature
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:
* Yang, Z. 2006. Computational Molecular Evolution.
* Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

Prerequisites / notice
Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly encourage to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

636-0108-00L

<table>
<thead>
<tr>
<th>Biological Engineering and Biotechnology</th>
<th>W</th>
<th>4 credits</th>
<th>3V</th>
<th>M. Fussenegger</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td></td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
<td></td>
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<tr>
<td><strong>Objective</strong></td>
<td></td>
<td>Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td></td>
<td>Handout during the course.</td>
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636-0507-00L

<table>
<thead>
<tr>
<th>Synthetic Biology II</th>
<th>W</th>
<th>8 credits</th>
<th>4A</th>
<th>S. Panke, Y. Benenson, J. Stelling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td></td>
<td>7 months biological design project, during which the students are required to give presentations on advanced topics in synthetic biology (specifically genetic circuit design) and then select their own biological system to design. The system is subsequently modeled, analyzed, and experimentally implemented. Results are presented at an international student competition at the MIT (Cambridge).</td>
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<tr>
<td><strong>Objective</strong></td>
<td></td>
<td>The students are supposed to acquire a deep understanding of the process of biological design including model representation of a biological system, its thorough analysis, and the subsequent experimental implementation of the system and the related problems.</td>
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<tr>
<td><strong>Content</strong></td>
<td></td>
<td>Presentations on advanced synthetic biology topics (eg genetic circuit design, adaptation of systems dynamics, analytical concepts, large scale de novo DNA synthesis), project selection, modeling of selected biological system, design space exploration, sensitivity analysis, conversion into DNA sequence, (DNA synthesis external,) implementation and analysis of design, summary of results in form of scientific presentation and poster, presentation of results at the iGEM international student competition (<a href="http://www.igem.org">www.igem.org</a>).</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td></td>
<td>Handouts during course.</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td></td>
<td>The final presentation of the project is typically at the MIT (Cambridge, US). Other competing schools include regularly Imperial College, Cambridge University, Harvard University, UC Berkeley, Princeton University, CalTech, etc. This project takes place between end of Spring Semester and beginning of Autumn Semester. Registration in April. Please note that the number of ECTS credits and the actual work load are disconnected.</td>
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701-1703-00L

<table>
<thead>
<tr>
<th>Evolutionary Medicine for Infectious Diseases</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>A. Hall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of participants limited to 35.</strong></td>
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<tr>
<td><strong>Abstract</strong></td>
<td></td>
<td>This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.</td>
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<tr>
<td><strong>Objective</strong></td>
<td></td>
<td>Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating pathogens of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.</td>
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<tr>
<td><strong>Content</strong></td>
<td></td>
<td>We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (~20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.</td>
<td></td>
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<tr>
<td><strong>Literature</strong></td>
<td></td>
<td>The focus is on primary literature, but for some parts the following text books provide good background information: Schmid Hempel 2011 Evolutionary Parasitology Stearns &amp; Medzhovit 2016 Evolutionary Medicine</td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td></td>
<td>A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.</td>
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752-3105-00L

<table>
<thead>
<tr>
<th>Physiology Guided Food Structure and Process Design</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>E. J. Windhab, M. Devezeaux de Lavergne,</th>
</tr>
</thead>
</table>
A 'cook-and-look' approach to process design is no longer applicable in the current environmental, nutritional and competitive constraints. The modern R&D chemical/food engineer should have a clear focus on the desired structure that needs to be achieved to design a process line or a processing equipment, coupled with in depth knowledge of the processed materials.

The objective of this course is to highlight the intimate links between human physiology and product sensory and nutritional functions. To optimize these functions, an understanding of the physiological functions that interact and encode the actions of those product structures must be well understood.

The objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures. Therefore the objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures.

The students will be exposed to this interplay all along the GI tract, including taste, aroma and texture perception, swallowing mechanics and gastro intestinal digestion with an engineering or physical sciences angle.

752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loessner, M. Schmelcher, M. Schuppler, E. Wetter, Slack

Abstract
The course offers detailed information on selected foodborne pathogen's and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60 minutes (10:15 until approx. 11:15 h), without a break!

752-6101-00L Dietary Etiologies of Chronic Disease W 3 credits 2V M. B. Zimmermann

Abstract
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Objective
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.

Content
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Lecture notes
There is no script. Powerpoint presentations will be made available on-line to students.

Literature
To be provided by the individual lecturers, at their discretion.

Prerequisites / notice
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

752-6105-00L Epidemiology and Prevention W 3 credits 2V M. Puhan, R. Huesser

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<td>Communication</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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</table>

ECTS: 3
Hours: 2V
Lecturers: M. B. Zimmermann, R. Huesser

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1208 of 2416
Content
What is translational science and what is it not?
How to identify need?
- Disease concepts and consequences for research
- Basics about incidence, prevalence etc., and orphan indications
- How to choose the appropriate research type and methodology
- Ethical considerations including ethics application
- Pros and cons of different types of research
- Coordination of complex approaches incl. timing and resources
- How to measure success?
- Outcome variables
- Improving the translational process
- Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences
Positive and negative examples will be illustrated by distinguished guest speakers.

376-0302-01L GCP Basic Course (Modules 1 and 2) O 1 credit 1G G. Senti, C. Fila, R. Grossmann
Only for Health Sciences and Technology MSc.

Abstract
The basic course in “Good Clinical Practice” (GCP) contains of two full-time training days (Module 1 and Module 2) and addresses elementary aspects for the appropriate conduct of clinical trials and non-clinical research projects involving human beings. Successful participation will be confirmed by a certificate that is recognized by the Swiss authorities.

Objective
Students will get familiar with:
- Key Ethics documents
- (International) Guidelines and Laws (e.g. ICH-GCP, DIN EN ISO 14155, TPA, HRA)
- Sequence of research projects and project-involved parties
- Planning of research projects (statistics, resources, study design, set-up of the study protocol)
- Approval of research projects by Authorities (SwissEthics, Swissmedic, FOPH)
- Roles and responsibilities of project-involved parties

Students will learn how to:
- Classify research projects according the risk-based approach of the HRA
- Write a study protocol
- Inform participating patients/study subjects
- Obtain consent by participating patients/study subjects
- Classify, document and report Adverse Events
- Handle projects with biological material from humans and/or health-related personal data

Content
Module 1:
Research and Research Ethics, Guidelines, (International) Legislation, Development of therapeutic products, Methodology (Study Design), Study documents (Study protocol, Investigator's Brochure, Patient Information Leaflet, Informed Consent Form)

Module 2:
Roles and Responsibilities, Approval procedures, Notification and Reporting, Study documentation, Research with biological material and health-related data, data protection, data retention

★★ Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>E. Konukoglu, F. Yu</td>
</tr>
<tr>
<td>Objective</td>
<td>Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.</td>
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<tr>
<td>Content</td>
<td>This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.</td>
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<tr>
<td>Lecture notes</td>
<td>Course material Script, computer demonstrations, exercises and problem solutions</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.</td>
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</table>

| 227-1037-00L | Introduction to Neuroinformatics | W    | 6 credits | 2V+1U+1A | V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens |
| Abstract  | The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented. |
| Objective | Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions. |
This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained. Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

### 327-1047-00L

**Consciousness: From Philosophy to Neuroscience (University of Zurich)**

*No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.*

**UZH Module Code:** INI410

**Mind the enrolment deadlines at UZH:**

https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

**Objective**

The course's goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought by modern cognitive neuroscience. We aim to clarify concepts, explain their philosophical and scientific backgrounds, and to present experimental protocols that shed light on a variety of consciousness related issues.

**Content**

The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of consciousness, and proposals for the neural correlate of consciousness (NCC).

**Lecture notes**

None

**Literature**

We display articles pertaining to the issues we cover in the class on the course's webpage.

Since we are all experts on consciousness, we expect active participation and discussions!

### 327-2125-00L

**Microscopy Training SEM I - Introduction to SEM**

The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs, and others, a fee will be charged (https:// scopem.ethz.ch/education/MP70.html).

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

**Abstract**

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

**Objective**

- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

**Content**

During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications.

This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis.

Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

**Lectures:**

- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

**Practicals:**

- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

**Lecture notes**

Lecture notes will be distributed.

**Literature**


**Prerequisites / notice**

No mandatory prerequisites.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1210 of 2416
For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP0.html).

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract

The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

Objective

Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data

Content

Lectures:
- basics of electron optics and the TEM instrument set-up
- TEM imaging modes and image contrast
- STEM operation mode
- Sample preparation techniques for hard and soft materials

Practicals:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

Lecture notes

Lecture notes will be distributed.

Literature


Prerequisites / notice

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

376-0221-00L Methods and Concepts in Human Systems Neuroscience and Motor Control □

Does not take place this semester.

Abstract

This course provides hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (nerve/brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students read scientific material, set up experiments, perform measurements in the lab, analyse data, apply statistics and write short reports or essays.

Objective

This course will prepare students for experimental work as it is typically done during the master thesis. The goal is to gain hands-on experience with measurement and analysis methods relevant for Humans Systems Neuroscience and Motor control (for example peripheral nerve stimulation, electrical and magnetic brain stimulation, EMG, EEG, psycho-physical paradigms etc). Students will learn how to perform small scientific projects in this area. Students will work individually or in small groups and solve scientific problems which require them to perform measurements in human participants, extract relevant readouts from the data, apply appropriate statistics and interpret the results. They will also be required to write small essays and reports and they will get feedback on their writing throughout the course.

Content

Students are required to have successfully completed the course “Neural control of movement and motor learning” and to have basic knowledge of applied statistics.

376-0816-00L Applied Human Research Project Management □

Abstract

This course equips the students with several key principles such as good clinical practice, ethical study requirements, reproducible data management and effective oral, graphical, and written communication to design and manage good quality, ethically sound human research studies. It represents a 101-toolkit of transferable research management skills/digital tools.

Objective

The overall goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Create/select well-founded research hypothesis and study designs for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects
- Integrate principles of effective communication in speaking, writing and graphical illustrations of future research idea/output

Content

The course will cover the following topics:

- Introduction to different study designs and ethical requirements thereof in Switzerland
- Introduction to literature search and searching platforms
- How to collect and sort publications/ keep up to date on research topic
- Inputs on critically evaluating papers
- How to pre-define study requirements to "future-proof" the research (hypothesis, sample size definition, pre-registration)
- Correct conduction of fundamental human research procedures (e.g., screening, consent process, CRF) and identification/prevention of deviations and emergencies (e.g., SAE/AE; protocol violation, research misconduct)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metatolls)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

376-1151-00L Translation of Basic Research Findings from Genetics and Molecular Mechanisms of Aging □

Abstract

The original goal of this course is to integrate transferable principles of human research project management into preparation, conduction, and dissemination of own/future research projects and beyond. The following objectives are part of this course:

- Create/select well-founded research hypothesis and study designs for a specific research topic
- Apply universal good clinical practice guidelines in future research projects
- Integrate well-documented data management and open science principles into future research projects
- Integrate principles of effective communication in speaking, writing and graphical illustrations of future research idea/output

Content

The course will cover the following topics:

- Introduction to different study designs and ethical requirements thereof in Switzerland
- Introduction to literature search and searching platforms
- How to collect and sort publications/ keep up to date on research topic
- Inputs on critically evaluating papers
- How to pre-define study requirements to "future-proof" the research (hypothesis, sample size definition, pre-registration)
- Correct conduction of fundamental human research procedures (e.g., screening, consent process, CRF) and identification/prevention of deviations and emergencies (e.g., SAE/AE; protocol violation, research misconduct)
- Principles of reproducible and integral study documentation and data management (e.g., definition of source files, SOP/WI, Master Trial File, metatolls)
- FAIR principles and open science
- Design principles and free digital tools for graphical illustrations
- Effective summarizing of research output/topic in an abstract and pitch presentation

Prerequisites / notice

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

Number of participants limited to 12

Prerequisites / notice

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

Number of participants limited to 30

Prerequisites / notice

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

Number of participants limited to 12
Abstract
Recently, several start-up companies are aiming to translate basic molecular findings into new drugs/therapeutic interventions to slow aging or post-poke age-related diseases (e.g., Google founded Calico or Craig Venter's Human Longevity, Inc.). This course will teach students the basic skill sets to formulate their own ideas, design experiments to test them and explains the next steps to translate.

Objective
The overall goal of this course is to be able to analyse current therapeutic interventions to identify an unmet need in molecular biology of aging and apply scientific thinking to discover new mechanisms that could be used as a novel therapeutic intervention. Learning objectives include:
1. Evaluate the current problem of our aging population, the impact of age-dependent diseases and current strategies to prevent these age-dependent diseases.
2. Analyse/compare current molecular/genetic strategies that address these aging problems.
3. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
4. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them

Content
Overview of aging and age-related diseases. Key discoveries in molecular biology of aging. Case studies of biotech companies addressing age-related complications. Brief introduction from bench to bedside with focus on start-up companies.

Prerequisites / notice
No compulsory prerequisites, but student should have basic knowledge about genetics and molecular biology.

376-1177-00L Human Factors I
W 3 credits 2V M. Menozzi Jäckli, R. Huang, M. Siegrist

Abstract
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.

Objective
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

376-1179-00L Applications of Cybernetics in Ergonomics
W 1 credit 1U M. Menozzi Jäckli, Y.-Y. Hedinger Huang, R. Huang

Abstract
Cybernetics systems have been studied and applied in various research fields, such as for applications in ergonomics. Topics discussed in this lecture (man-machine-interaction, performance in multi-modal interactions, quantification in gestalt principles for the use in product development, information processing) are deepened with exercises conducted at our labs.

Objective
To learn and practice cybernetics principles in interface designs and product development.

Content
- Fitt's law applied in manipulation tasks
- Hick-Hyman law applied in design of the driver assistance systems - Vigilance applied in quality inspection
- Accommodation/vergence crosslink function
- Cross-link models in neurobiology- the ocular motor control system
- Human performance in optimization of production lines

Literature

376-1305-00L Development of the Nervous System (University of Zurich)
W 3 credits 2V University lecturers

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: BIO344

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Objective
On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development
- apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills
On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Learning objectives include:
1. Analyse/compare current molecular/genetic strategies that address these aging problems.
2. Analyse case studies about biotech companies in the aging sector. Apply the scientific methods to formulate basic research questions to address these problems.
3. Generate own hypotheses (educated guess/idea), design experiments to test them, and map out the next steps to translate them.

Furthermore, the lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
BIO142 Developmental Biology, BIO143 Neurobiology

376-1305-01L Neural Systems for Sensory, Motor and Higher Brain
W 3 credits 2V G. Schratt, J. Bohacek, R. Fiore,
The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.

The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle / OLAT.

### 376-1414-00L Current Topics in Brain Research (HS)

**Objective**

To exchange scientific knowledge and data and to promote communication and collaborations among researchers. For students: Critical discussion of current research. Students aiming at getting a credit point for this colloquium choose one topic and write a critical essay on the presented research topic.

### 376-1504-00L Physical Human Robot Interaction (pHRI)

**Objective**

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de- sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

### Content

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

**Lecture notes**

Will be distributed on Moodle before the lectures.
Abstract

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective

The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Notice:
The registration is limited to 26 students.

There are 4 credit points for this lecture.

The lecture will be held in English.

The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html

Literature


Prerequisites / notice

Notice:
The registration is limited to 26 students.
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html

376-1561-00L

Ethics of Life Sciences and Biotechnology

W 3 credits 2V A. Blasimme, E. Vayena

Number of participants limited to 100

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

376-1723-00L

Big Data Analysis in Biomedical Research

W 4 credits 2V+2U E. Araldi, M. Ristow

Number of participants limited to 20

Biomedical datasets are increasing in size and complexity, and discoveries arising from their analysis have important implications in human health and biotechnological advances. While the potential of biomedical dataset analysis is considerable, preclinical researchers often lack the computational tools to analyze them. This course will provide the basis of data analysis of large biomedical data.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1214 of 2416
This course aims to provide practical tools to analyze large biomedical datasets, and it is tailored towards experimental researchers in the life sciences with minimal prior programming experience, but with a strong interest in exploring big data to solve own research problems. Through theoretical classes, practical demonstrations, in class exercises and homework, the participants will master computational methods to independently manipulate large datasets, effectively visualize big data, and analyze it with appropriate statistical tools and machine learning approaches. For the final assessment, students will conduct an independent data analysis project based on a biomedical problem of their choosing and using publicly available population-based biomedical datasets.

While learning the programming skills needed to manipulate and visualize the data, participants will learn the statistical and modeling approaches for big data analysis. The course will cover:
- Basics of Python programming and UNIX;
- High performance computing;
- Manipulation and cleaning of large datasets with Pandas;
- Visualization tools (Matplotlib, Seaborn);
- Machine learning and numerical libraries (SciPy, NumPy, Statsmodels, Scikit-Learn);
- Statistical analysis and modeling of big data, and applications to biomedical datasets (statistical learning, distributions, linear and logistic regressions, principal component analysis, clustering, classification, time series analysis, tree-based methods, predictive models).

Basic understanding of mathematics and statistics, as taught in basic courses at the Bachelor’s level.

**Objective**

**Content**

**Prerequisites / notice**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>W</th>
<th>Credits</th>
<th>V</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0309-00L</td>
<td>Concepts in Modern Genetics</td>
<td></td>
<td>6</td>
<td>4V</td>
<td>Y. Barral, D. Bopp, A. Hajnal, O. Voinnet</td>
</tr>
<tr>
<td></td>
<td><em>Information for UZH students:</em></td>
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<tr>
<td></td>
<td>Enrolment to this course unit only possible at ETH. No enrolment to module BIO348 at UZH.</td>
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<td><em>Please mind the ETH enrolment deadlines for UZH students:</em> <a href="https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html">https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html</a></td>
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</table>
|             | **Abstract**                                      |   |         |    | C:
|             | Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference. |
|             | **Objective**                                     |   |         |    | This course focuses on the concepts of classical and modern genetics and genomics. |
|             | **Content**                                       |   |         |    | The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference. |
|             | **Lecture notes**                                 |   |         |    | Scripts and additional material will be provided during the semester. |

**551-0317-00L** Immunology I

**Abstract**

Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.

**Objective**

Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**

- Introduction and historical background
- Innate and adaptive immunity. Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

**Lecture notes**

Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**

For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

**551-0319-00L** Cellular Biochemistry (Part I)

**Abstract**

Yeast genetics; gene mapping; forward and reverse genetics; eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**

- Vaccines, immune-therapeutic interventions
- Hypersensitivities
- Allergies
- Th1 and Th2 cells, regulatory T cells
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- B cells and antibodies
- Generation of diversity
- Innate and adaptive immunity. Cells and organs of the immune system

**Lecture notes**

Scripts and additional material will be provided during the semester.

**Literature**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Fostered competencies**

**Method-specific Competencies**

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**551-0320-00L** Cellular Biochemistry (Part II)

**Abstract**

Yeast genetics; gene mapping; forward and reverse genetics; eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**

Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**

- Vaccines, immune-therapeutic interventions
- Hypersensitivities
- Allergies
- Th1 and Th2 cells, regulatory T cells
- Antigen presentation and Major Histocompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- B cells and antibodies
- Generation of diversity
- Innate and adaptive immunity. Cells and organs of the immune system

**Lecture notes**

Scripts and additional material will be provided during the semester.

**Literature**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**

- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Fostered competencies**

**Method-specific Competencies**

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1215 of 2416
Abstract

Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterization of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

Content

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Lecture notes

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

752-4009-00L Molecular Biology of Foodborne Pathogens

W 3 credits 2V M. Loeser, M. Schmelcher, M. Schuppler, E. Wetter Sladk

Abstract

The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective

Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content

Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature

Recommendations will be given in the first lecture.

Prerequisites / notice

Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break !

752-6403-00L Nutrition and Performance

W 2 credits 2V S. Mettler, M. B. Zimmermann

Abstract

The course introduces basic concepts of the interaction between nutrition and exercise performance.

Objective

To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise.

Content

The course will cover elemental aspects of sports nutrition physiology, including carbohydrate, glycogen, fat, protein and energy metabolism. A main focus will be to understand nutritional aspects before exercise to be prepared for intensive exercise bouts, how exercise performance can be supported by nutrition during exercise and how recovery can be assisted by nutrition after exercise.

Lecture notes

Lecture slides and required handouts will be available on the ETH website (moodle).

Literature

Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.

Prerequisites / notice

General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course. The course builds on basic nutrition and biochemistry knowledge to address exercise and performance related aspects of nutrition.

The course is designed for 3rd year Bachelor students, Master students and postgraduate students (MAS/CAS).

Practical Training

Practical Training only for majors mentioned below:
- Human Movement Science and Sport
- Medical Technology
- Molecular Health Sciences
- Neurosciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2110-00L</td>
<td>Practical Training 12 Weeks (Job or Research Oriented)</td>
<td>W</td>
<td>15 credits</td>
<td></td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school).</td>
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<tr>
<td>Objective</td>
<td>Students should exercise scientific working and/or get realistic insights into future jobs.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This version of internships lasts for at least 12 weeks full time equivalent.</td>
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</table>

| 376-2111-00L | Practical Training 8 Weeks (Job or Research Oriented) | W | 10 credits | | Supervisors |
| Abstract | Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school). |
| Objective | Students should exercise scientific working and/or get realistic insights into future jobs. |
| Prerequisites / notice | This version of internships lasts for at least 8 weeks full time equivalent. |

| 376-2112-00L | Practical Training 4 Weeks (Job or Research Oriented) | W | 5 credits | | Supervisors |
| Abstract | Practical Training Internships are either research-oriented for exercising scientific (laboratory) methods or job-related for giving insight into the future world of work (industry, services, school). |
| Objective | Students should exercise scientific working and/or get realistic insights into future jobs. |
Prerequisites / notice

This version of internships lasts for at least 4 weeks full time equivalent.

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### Research Internship

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-2100-00L</td>
<td>Research Internship</td>
<td>O</td>
<td>15</td>
<td></td>
<td>Supervisors</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>12-week internship intended for exercising (independent) scientific working.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Students shall exercise scientific working as preparation for their master thesis.</td>
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### Master’s Thesis

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>376-2000-00L</td>
<td>Master's Thesis</td>
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<td>30</td>
<td>71D</td>
<td>Supervisors</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>6-months research study with topics from the chosen major within the field of Health Sciences and Technology. In general, it includes the study of existing literature, the specification of the research question, the choice of the methodological approach, the collection, analysis and interpretation of data, and the written and oral reporting of the findings.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The students shall demonstrate their ability to carry out a structured, scientific piece of work independently.</td>
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</tbody>
</table>

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### Course Units for Additional Admission Requirements

*The courses below are only for MSc students with additional admission requirements.*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>406-0253-AAL</td>
<td>Mathematics I &amp; II</td>
<td>E-</td>
<td>13</td>
<td>28R</td>
<td>A. Cannas da Silva, F. Da Lio</td>
</tr>
<tr>
<td></td>
<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Mathematics I covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems, notably through linear algebra and calculus, with an emphasis on ordinary differential equations.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The main focus of Mathematics II is multivariable calculus.</td>
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<tr>
<td></td>
<td>Content</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>1. Linear Algebra and Complex Numbers: systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>3. Ordinary Differential Equations: separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.</td>
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<tr>
<td></td>
<td>4. Multivariable Differential Calculus: functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.</td>
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<tr>
<td></td>
<td>5. Multivariable Integral Calculus: multiple integrals, line and surface integrals, work and flow, Green, Gauss and Stokes theorems, applications.</td>
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</table>

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### Movement and Sport Biomechanics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>376-0203-AAL</td>
<td>Movement and Sport Biomechanics</td>
<td>E-</td>
<td>4</td>
<td>3R</td>
<td>B. Taylor, N. Singh</td>
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<td>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</td>
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</tbody>
</table>
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course!

Abstract
Learning to view the human body as a (bio-)mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

Objective
"Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics."

Content
Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

406-0062-AAL  Physics I  Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Objective
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts in mechanics.

Content

Chapters:
1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature
see "Content"

Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 1: Mechanik und Thermodynamik
Wiley-VCH Verlag, 2002, 544 S, ca.: Fr. 68.-

376-1714-AAL  Biocompatible Materials  Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.

Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

Available online via ETH library

Handouts and references therein.

Health Sciences and Technology Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
High-Energy Physics (Joint Master with IP Paris)

Core Subjects

Core Courses in Theoretical Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0843-00L</td>
<td>Quantum Field Theory I</td>
<td>W</td>
<td>10 credits</td>
<td>4V+2U</td>
<td>R. Renner</td>
</tr>
</tbody>
</table>

Abstract
This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity.
Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

Objective
The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

Core Courses in Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0891-00L</td>
<td>Phenomenology of Particle Physics I</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>P. Crivelli, A. de Cosa</td>
</tr>
</tbody>
</table>

Abstract
Topics to be covered in Phenomenology of Particle Physics I:
Relativistic kinematics
Decay rates and cross sections
The Dirac equation
From the S-matrix to the Feynman rules of QED
Scattering processes in QED
Experimental tests of QED
Hadron spectroscopy
Unitary symmetries and QCD
QCD and alpha_s running
QCD in e^+e^- annihilation
Experimental tests of QCD in e^+e^- annihilation

Objective
Introduction to modern particle physics

Content
Topics to be covered in Phenomenology of Particle Physics I:
Relativistic kinematics
Decay rates and cross sections
The Dirac equation
From the S-matrix to the Feynman rules of QED
Scattering processes in QED
Experimental tests of QED
Hadron spectroscopy
Unitary symmetries and QCD
QCD and alpha_s running
QCD in e^+e^- annihilation
Experimental tests of QCD in e^+e^- annihilation

Electives

Optional Subjects in Physics

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0457-00L</td>
<td>Quantum Technologies for Searches of New Physics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Crivelli, D. Kienzler</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1219 of 2416
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

The aim of this course is to equip students of different backgrounds with a solid base to follow the rapidly developing and exciting multidisciplinary field.

The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.

- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

You will be able to present and discuss:

- experimental methods to measure cosmic ray particles over full energy range
- current knowledge about the composition of cosmic ray
- possible cosmic acceleration mechanisms
- correlation between astronomical object classes and cosmic accelerators

Successful students know:

- definition of 'Astro-Particle Physics'
- important historical experiments
- chemical composition of the cosmic rays
- direct observations of cosmic rays
- indirect observations of cosmic rays
- 'extended air showers' and 'cosmic muons'
- 'knee' and 'ankle' in the energy spectrum
- the 'anti-matter problem' and the Big Bang

The following are recommended.

- various techniques: detectors, cryogenics, particle beams, laser cooling....
- ultra-cold neutron production
- 'anti-matter problem'
- 'cosmic accelerators'

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrinos and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:

- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spin manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling....

The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

This lecture gives an overview of the present research in the field of Astro-Particle Physics, including the different experimental techniques.

The first semester, main topics are the charged cosmic rays including the antimatter problem. The second semester focuses on the neutral components of the cosmic rays as well as on some aspects of Dark Matter.

Content

Successful students know:

- experimental methods to measure cosmic ray particles over full energy range
- current knowledge about the composition of cosmic ray
- possible cosmic acceleration mechanisms
- correlation between astronomical object classes and cosmic accelerators

Abstract

This lecture gives an overview of the present research in the field of Astro-Particle Physics, including the different experimental techniques. In the first semester, main topics are the charged cosmic rays including the antimatter problem. The second semester focuses on the neutral components of the cosmic rays as well as on some aspects of Dark Matter.
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

Suggested textbooks:
- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- C. Misner, K, Thorne and J. Wheeler: Gravitation
- S. Weinberg - Gravitation and Cosmology
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

Subject-specific Competencies
- 9. MC simulations (GEANT), trigger, readout, electronics
- 8. Special detectors: extended airshower detectors and cryogenic detectors
- 7. Analysis methods: invariant and missing mass, jet algorithms, b-tagging
- 6. Particle identification
- 5. Calorimetry
- 4. Charged particle tracking and vertexing
- 3. Physics and layout of accelerators
- 2. Basics: Bethe-Bloch, radiation length, nucl. interaction length, fixed-target vs. collider, principles of measurements: energy- and momentum-conservation, etc
- 1. Examples of modern experiments

Examples of key experiments.

General Relativity

Suggested textbooks:
- C. Misner, K, Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

Effective Field Theories for Particle Physics

The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. These topics will be discussed both in general terms and with specific phenomenological applications in the context of physics beyond the Standard Model, effective description of the weak interaction, as well as the description of non-perturbative strong interaction at low energies.
Objective
This course covers the basic concepts of effective field theories (EFTs) and dispersion theory. We will start by introducing the core concept of constructing EFTs and apply them to the low-energy description of the weak interaction and the effective description of heavy physics beyond the Standard Model.

In the next part of the course, we will discuss Chiral Perturbation Theory (ChPT), the low-energy effective theory of Quantum Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

Content
- Introduction to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

Prerequisites / notice
QFT-I (mandatory) and QFT-II (highly recommended)

402-0845-80L Scattering Amplitudes W 6 credits 2V+1U V. Del Duca

Special Students UZH must book the module PHY577 directly at UZH.

Abstract
This course provides a pedagogical introduction to an advanced topic in Quantum Field Theories, which has undergone a tremendous progress in the new millennium: scattering amplitudes and on-shell methods.

Objective
Students that complete the course will be able to understand the basics of the modern methods to compute scattering amplitudes, to perform simple calculations and to read modern publications on this research field.

Content
This course covers the basic concepts of:
-- spinor helicity formalism
-- colour decompositions
-- on-shell recursion relations
-- colour-kinematics duality
-- scattering equations
-- unitarity:
  * optical theorem
  * uniqueness of Yang-Mills
  * uniqueness of General Relativity
  * unitarity method
-- Feynman integrals: IBPs and differential equations
-- analytic and algebraic structure of loop-level amplitudes:
  * Hopf algebra, symbols and coproducts
  * multiple polylogarithms (a.k.a. as iterated integrals on the Riemann sphere)
  * elliptic and modular-form integrals (a.k.a. as iterated integrals on the torus)

Prerequisites / notice
A basic knowledge of Feynman rules in scalar field theories and in Yang-Mills theory is assumed.

QFT-I, QFT-II and Introduction to Quantum ChromoDynamics are highly recommended.

402-0851-00L QCD: Theory and Experiment W 3 credits 3G to be announced, University lecturers

Abstract
An introduction to the theoretical aspects and experimental tests of QCD, with emphasis on perturbative QCD and related experiments at colliders.

Objective
Knowledge acquired on basics of perturbative QCD, both of theoretical and experimental nature. Ability to perform simple calculations of perturbative QCD, as well as to understand modern publications on theoretical and experimental aspects of perturbative QCD.

Content
QCD Lagrangian and Feynman Rules
QCD running coupling
Parton model
DGLAP
Basic processes
Experimental tests at lepton and hadron colliders
Measurements of the strong coupling constant

Literature
2) R. K. Ellis, W. J. Stirling, B. R. Webber : "QCD and Collider Physics" (Cambridge Monographs on Particle Physics, Nuclear Physics & Cosmology)"

Prerequisites / notice
For students of both ETH and University of Zurich.

402-0870-00L Introduction to Quantum Electrodynamics W 6 credits 2V+1U A. Lazopoulos

Abstract
This course provides a pedagogical introduction to Quantum Electrodynamics.

Objective
Students will be introduced to the theory of Quantum Electrodynamics, and to using Feynman diagrams to arrive at theoretical predictions for phenomena related to the interaction of light and matter. The course is designed to complement Quantum Field Theory I for those students with a special interest in elementary particle physics.
The course will cover:
- an introduction to QED as the quantum theory of interactions of light and matter.
- Feynman rules for QED
- An introduction to helicity and spinors
- Amplitudes and cross sections for simple processes in QED
- Infinites and Renormalization
- The Hydrogen atom
- The Lamb shift
- Anomalous magnetic moments

Lecture notes: Will be provided at the Moodle site for the course.

Literature: Will be provided at the Moodle site for the course.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Weeks</th>
<th>Credits</th>
<th>Lectures</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>402-0886-00L</td>
<td>Quantum Chromodynamics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>T. K. Gehrmann</td>
</tr>
<tr>
<td>402-0887-00L</td>
<td>Introduction to String Theory</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td></td>
</tr>
<tr>
<td>402-0889-65L</td>
<td>Higgs Physics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>M. Donegà, M. Grazzini</td>
</tr>
</tbody>
</table>

Abstract:
- The course presents the quantum field theory of the strong interaction (quantum chromodynamics, QCD) and discusses its applications to particle physics observables.
- The course aims to familiarize its students with the concepts and applications of QCD and to introduce them to modern techniques for computations in QCD.

Content:
- Review of non-Abelian gauge theories and their quantization
- Spinor-helicity formalism
- Renormalization of QCD and running coupling constant
- Basic strong interaction processes
- Perturbation theory techniques: loops and phase space
- QCD perturbation theory and applications
- Proton structure in QCD
- Resummation of large logarithmic corrections
- Effective field theories
- Non-perturbative methods

Prerequisites / notice:
- The course assumes prior knowledge of the content of the quantum field theory 1+2 lectures.

Abstract:
- String theory is an attempt to quantise gravity and unite it with the other fundamental forces of nature. It is related to numerous interesting topics and questions in quantum field theory. In this course, an introduction to the basics of string theory is provided.

Objective:
- Within this course, a basic understanding and overview of the concepts and notions employed in string theory shall be given. More advanced topics will be touched upon towards the end of the course briefly in order to foster further research.

Content:
- Mechanics of point particles and extended objects
- String modes and their quantisation; higher dimensions, supersymmetry
- D-branes, T-duality
- Supergravity as a low-energy effective theory, strings on curved backgrounds
- Two-dimensional field theories (classical/quantum, conformal/non-conformal)

Literature:

Prerequisites / notice:
- Recommended: Quantum Field Theory I (in parallel)

Higgs properties and Beyond the Standard Model perspective

Outlook: The Higgs sector in weakly coupled and strongly coupled new physics scenarios.

Experimental part:

Introductory material:
- basics of accelerators and detectors
- reminders of statistics: likelihoods, hypothesis testing
- reminders of multivariate techniques: Boosted Decision Trees and Neural Networks

Main topics:
- pre-history (pre-LEP)
- LEP1: measurements at the Z-pole
- Electroweak constraints
- LEP2: towards the limit mH<114 GeV
- TeVatron searches
- LHC
  -- main channels overview
  -- dissect one analysis
  -- combine information from all channels
  -- differential measurements
  -- off-shell measurements

Literature
- Higgs Hunter's Guide
  (by S.Dawson, J. Gunion, H. Haber and G. Kane)
- "Combination of Tevatron searches for the standard model Higgs boson in the W+W- decay mode" HWW TeVatron combination - http://arxiv.org/abs/1001.4162
- "Evidence for a particle produced in association with weak bosons and decaying to a bottom-antibottom quark pair in Higgs boson searches at the TeVatron" http://arxiv.org/abs/1207.8436
- "Precise determination of the mass of the Higgs boson and tests of compatibility of its couplings with the standard model predictions using proton collisions at 7 and 8 TeV" https://arxiv.org/abs/1412.8662
- "Measurements of the Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data at √s=7 and 8 TeV" https://arxiv.org/abs/1606.02266
- "Predictions of Higgs Boson measurements with 30 fb at 8 TeV and 300 fb at 14 TeV" https://twiki.cern.ch/twiki/bin/view/CMSPublic/HigProjectionESg2012TWiki

Prerequisites / notice
Prerequisites: Quantum Field Theory I, Phenomenology of Particle Physics I

★★ Optional Subjects in Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3531-00L</td>
<td>Differential Geometry I</td>
<td>W</td>
<td>10 credits</td>
<td>4V+1U</td>
<td>J. Serra</td>
</tr>
<tr>
<td>401-3461-00L</td>
<td>Functional Analysis I</td>
<td>W</td>
<td>10 credits</td>
<td>4V+1U</td>
<td>P. Hintz</td>
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Number Title
401-3531-00L Differential Geometry I
At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract

Objective
Introduce the classical theory of curves and surfaces (which is the precursor of modern Riemannian geometry). Invite students to use and sharpen their geometric intuition.

Introduce the language, basic tools, and some fundamental results in modern differential geometry.

Lecture notes
Partial lecture notes are available from Prof. Lang's website https://people.math.ethz.ch/~lang/

Literature
- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- John M. Lee: Introduction to Smooth Manifolds
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie, Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1224 of 2416
Experimental Foundations of Particle Physics

Abstract
Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed range theorem; spectral theory of self-adjoint operators in Hilbert spaces.

Objective
Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature
Recommended references include the following:


To organise a semester project take contact with one of the instructors.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0717-MSL</td>
<td>Particle Physics at CERN</td>
<td>W</td>
<td>8</td>
<td>15P</td>
<td>W. Lustermann</td>
</tr>
<tr>
<td>402-0719-MSL</td>
<td>Particle Physics at PSI (Paul Scherrer Institute)</td>
<td>W</td>
<td>8</td>
<td>15P</td>
<td>A. Soter, A. S. Antognini</td>
</tr>
<tr>
<td>402-0210-MSL</td>
<td>Proseminar Theoretical Physics</td>
<td>W</td>
<td>8</td>
<td>4S</td>
<td>Supervisors</td>
</tr>
<tr>
<td>402-0217-MSL</td>
<td>Proseminar Theoretical Physics</td>
<td>W</td>
<td>8</td>
<td>15A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Prerequisites / notice
Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part: Lebesgue integration and L^p spaces).
Content

The course will not follow the historical trajectory of experimental particle physics. It will instead try to give a modern view of the results of the experiments and show where they fit in the theoretical construction.

The students will read the original papers collected in the seminal text by Cahn and Goldhaber. The theory will be distilled to the very basics using the textbook by Bettini.

Introductory material:
- Review of basic relativistic kinematics (Lorentz transformations, invariant mass, etc.)
- Passage of particles through matter: Bethe Bloch dE/dx, bremsstrahlung, photon interactions, electromagnetic showers, hadronic showers, Cherenkov radiation, Transition Radiation

Experimental papers discussed in the course:
- Deep Inelastic scattering
- J/ψ and tau discovery
- strong interaction: gluons and jets (anti-k_t jet clustering)
- parity violation, neutrino observation, neutrino helicity
- neutral current, W/Z discovery
- number of neutrino families, muon pair production asymmetry, W+W- production
- top/bottom discoveries
- Higgs discovery and properties
- CP violation in the kaon system
- Neutrino oscillations

The course is completed with in class detector demonstrations:
- cloud chamber
- cosmics rays with plastic scintillators
- cerenkov light in water
- silicon detectors

Literature

Cahn, Goldhaber “Experimental Foundations of Particle Physics” (2nd edition), Cambridge University Press
Bettini, “Introduction to Elementary Particle Physics” Cambridge University Press

Prerequisites / notice

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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</table>

Method-specific Competencies

<table>
<thead>
<tr>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

402-0215-MSL Experimental Semester Project in Physics

Abstract

The aim of the project is to give the student experience in working in a research environment, carrying out physics experiments, analysing and interpreting the resulting data.

Objective

- conduct a project in a research laboratory,
- discuss their experimental results and conclusions in a team,
- present their experimental findings in written and oral form.

Prerequisites / notice


Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-PHYS

see Science in Perspective: Language Courses ETH/UZH

Master’s Thesis

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
402-2000-00L | Scientific Works in Physics | O | 0 | 0 | D. Kienzler

Target audience:
Master students who cannot document to have received an adequate training in working scientifically.

Directive

Abstract

Literature Review: ETH-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX; Mathematical Writing, AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.

Objective

Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.

462-0900-00L Master’s Thesis

Further information:
www.phys.ethz.ch/phys/education/master/msc-theses

Abstract

The Master's thesis is normally conducted in the fourth semester and concludes the degree programme. With the Master's thesis students verify their ability to undertake independent and scientifically structured work in the area of high energy physics.

Prerequisites / notice

The time limit for completing the Master's thesis is six months.
## High-Energy Physics (Joint Master with IP Paris) - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Human Medicine Bachelor

#### Bachelor Studies (Programme Regulations 2022)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>377-0105-00L</td>
<td>Musculoskeletal System</td>
<td>O</td>
<td>5 credits</td>
<td>5V</td>
<td>J. Goldhahn, O. Distler, C. Maake, M. Steinwachs, R. Stocker</td>
</tr>
<tr>
<td></td>
<td>Only for Human Medicine BSc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Structure and function of the human musculoskeletal system including its major disorders (acute and chronic).</td>
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<tr>
<td>Objective</td>
<td>- The students are able to participate in team discussions with correct technical language in the clinical daily routine.</td>
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<tr>
<td></td>
<td>- The students are able to describe the function of the musculoskeletal system of healthy people in a physiologically correct way.</td>
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<td></td>
<td>- The students are able to contribute to a therapy plan based on their knowledge of the regenerative capacity of the different tissues in the musculoskeletal system.</td>
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<td></td>
<td>- The students recognize pain as a leading symptom in diagnostics and successful therapy.</td>
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<td></td>
<td>- The students can assign and compare treatment methods for the most common acute and chronic clinical pictures.</td>
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</tr>
<tr>
<td>Content</td>
<td>The students learn about the structure and function of the musculoskeletal system and important disorders on the basis of exemplary clinical pictures. They also learn:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- About its tissue types as well as its function and regeneration.</td>
<td></td>
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<tr>
<td></td>
<td>- Important acute and chronic clinical pictures and their therapeutic principles.</td>
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<tr>
<td></td>
<td>In addition, further clinical pictures are presented in the form of seminars.</td>
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</tbody>
</table>

| 377-0107-00L | Nervous System                        | O    | 5 credits | 5V    | D. P. Wolfer, I. Amrein, J. Bohacek, D. Burdakov, G. Schratt, L. Slomianka, O. Ullrich, N. Wenderoth, further lecturers |
|             | Only for Human Medicine BSc          |      |          |       |                                               |
| Abstract    | Structure and function of the central and peripheral nervous system including its major disorders. |
| Objective   | Upon successful completion of this module, students should be able to: |
|             | 1. distinguish important cell types of the nervous system (neurons, glial cells) on the basis of their structure and function; |
|             | 2. correctly describe neurophysiological basics of stimulus conduction and processing in the peripheral and central nervous system; |
|             | 3. correctly name the organ structures and circuits involved in the development of the peripheral and central nervous system; |
|             | 4. associate the different brain areas with corresponding functions in homeostasis, sensory, motor and cognitive functions; |
|             | 5. identify clinical pictures associated with the loss of function of certain structures of the central and peripheral nervous system and to understand the mode of action of current therapeutic approaches. |
| Content     | In this module, students get an overview of the structure (anatomy) and function (physiology) of the peripheral and central nervous system as well as selected neurological diseases (pathophysiology). |
|             | The module is subdivided into a total of six subject areas: |
|             | 1. basics of neurophysiology, stimulus conduction and processing using the example of the motor end plate, peripheral nervous system, associated clinical pictures (myasthenia gravis) |
|             | 2. structure, circuits and pathways in the spinal cord, spinal nerves, motor stimulus conduction in the spinal cord, spinal cord lesions and pain |
|             | 3. anatomy and function of the brain stem and cranial nerves and their significance for motor and sensory functions, lesions (brain stem syndromes) |
|             | 4. anatomy and function of basal ganglia, thalamus and hypothalamus, control of the autonomic nervous system (homeostasis, food and water intake), basal ganglia defects using Parkinson's disease as an example |
|             | 5. anatomy and function of the cerebellum and vestibular system, fine control of motor functions, associative learning, cerebellar symptoms (ataxias), organ of equilibrium |
|             | 6. anatomy and function of the cerebrum, sensory and motor processing, cognition, learning and memory, neurodegenerative (Alzheimer) and neuropsychiatric (schizophrenia) disorders |

| 551-0033-00L | Molecular Genetics and Cell Biology   | O    | 5 credits | 5G    | J. Corn, F. Allain, K. Köhler                     |
|             | Only for Health Sciences and Technology BSc and Human Medicine BSc. |
| Abstract    | This course teaches the basic principles of evolution, cell biology, molecular biology, genetics and developmental biology using the example of humans. |
| Objective   | 1) Students can explain the importance of evolution for the development of humans and diseases. |
|             | 2) The students know the cell as the smallest unit of the body. They can explain how the functions of the cell are disturbed in certain diseases and where therapies intervene. They can describe the multiplication of cells in the body and show how errors in this multiplication can lead to diseases. |
|             | 3) The students know DNA as the basis of life. They can explain how the DNA information is stored and how this information can be reproduced and protected from damage. They can describe how the information is read and translated into proteins. They can explain which mechanisms at the level of DNA, RNA and proteins can cause diseases. |
|             | 4) Students can explain which technologies can be used to diagnose and treat diseases. |
|             | 5) Students can explain how people differ genetically and know the molecular basis of these differences. They can explain how these differences can lead to diseases and why some of these differences do not affect diseases. |
|             | 6) The students know the molecular causes of the most common hereditary diseases and can determine the probability of occurrence and transmission to offspring. |
|             | 7) Students can explain the biochemical and molecular basis of human reproduction and know the basic principles of human embryonic development. The students can explain which mechanisms can be disturbed by a faulty development. |

| 529-5000-00L | Chemistry (for Medical Students)     | O    | 4 credits | 3V+1U | S. Wolfrum                                     |
|             | Only for Human Medicine BSc          |      |          |       |                                               |
| Abstract    | The lecture teaches the most important fundamental concepts in chemistry (atomic structure, chemical bonds, thermodynamics and kinetics of chemical reactions, acid-base equilibria, types and reactivity of organic compounds, stereochemistry, biomolecules). Connections of chemical processes with medically important biochemical, physiological and pharmacological questions are highlighted. |
| Objective   | Understanding of the basic concepts of chemistry, Understanding the importance of chemical processes in human physiology and in the diagnosis and treatment of human disease. |
The lecture elaborates the fundamental concepts of chemistry. The organization of the lecture is guided by the two textbooks "Chemie für Mediziner" by Zeeck et al. and Schmuck et al., respectively, referred to below. Accordingly, the following major subject areas will be covered: Atomic structure, periodic table of the elements, types of chemical bonds, states of matter, heterogeneous equilibria, thermodynamics and kinetics of chemical reactions, salt solutions, acids and bases, oxidation and reduction, metal complexes, fundamentals of organic chemistry, important classes of organic compounds and their reactivities, stereochemistry, amino acids and peptides, carbohydrates, lipids, heterocycles, spectroscopy in chemistry and medicine.

Lecture notes
Scripts for individual subject areas will be provided electronically prior to the corresponding lectures.

Literature
There are no English translations of these textbooks.

Prerequisites / notice
There are no specific requirements.

### First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

#### Abstract
Fundamental principles of human medicine, Basic Life Support (BLS) and introduction to histology and microscopy.

#### Objective
After completion of the course, the students:
- have a basic understanding of elementary building blocks and processes as a basis for human medicine, e.g. cell structure and cycle.
- know basic terminology of anatomy.
- understand the process of medical care from first aid to rehabilitation.
- understand the advantages and disadvantages of emergency diagnostics, especially ultrasound.
- know the basics of microscopy and histology.
- have learned the basics of Basic Life Support:
  - recognize the symptoms of cardiovascular arrest.
  - alarm in an emergency according to the situation.
  - if available, they organize an AED and use it correctly and as quickly as possible.
  - perform sufficient chest compressions on the phantom.
  - perform effective ventilation on the phantom using a pocket mask.
  - will identify possible ventilation complications. Under certain circumstances, they will not attempt further ventilation.
  - will identify the limits of cardiopulmonary resuscitation.
  - under stress, they do not risk their own or other "helpers"' lives.
- based on a complex clinical case, students are familiarized with the course of medical care from initial treatment to rehabilitation. Basic terms, modules and processes are introduced. In addition, the students experience the basics of imaging techniques, especially ultrasound.
- the students complete the Basic Life Support course. After this training sequence, all participants should be able to initiate resuscitation measures in private and in-hospital settings.
- the students experience learning, teaching and working in the hospital sector as a social process and teamwork in which all senses and a wide range of skills are needed.
- in addition, the students experience in three workshops the basic process of a physiotherapeutic intervention with the concepts of clinical reasoning, therapeutic aspects and therapy progression. An intensive course in microscopy/histology enables students to perform microscopy independently and to understand histological sections of a histological sample, but also online.

#### Content
Based on a complex clinical case, students are familiarized with the course of medical care from initial treatment to rehabilitation. Basic terms, modules and processes are introduced. In addition, the students experience the basics of imaging techniques, especially ultrasound.

The students complete the Basic Life Support course. After this training sequence, all participants should be able to initiate resuscitation measures in private and in-hospital settings.

The students experience learning, teaching and working in the hospital sector as a social process and teamwork in which all senses and a wide range of skills are needed.

In addition, the students experience in three workshops the basic process of a physiotherapeutic intervention with the concepts of clinical reasoning, therapeutic aspects and therapy progression. An intensive course in microscopy/histology enables students to perform microscopy independently and to understand histological sections of a histological sample, but also online.
Interviewing techniques to acquire medically relevant information and building an adequate physician-patient relationship.

The students know:
- the components of a structured medical interview

The students can:
- perform a structured medical interview
- initiate an adequate relation to patients

Content
Mixed teaching methods, including lectures and training in groups with real patients and simulated patients.

Bachelor Studies (Programme Regulations 2018)

Courses in Organ Systems and Clinical Practice

Examination Block A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course will focus on the components and functions of the hematopoietic and the immune systems and on diseases affecting or caused by these systems.

Objective
1. The organization and development of hematopoiesis including hematopoietic stem cell development; the role of hematopoietic growth and transcription factors in hematopoiesis; the role of hemoglobin in health and disease; erythrocytosis and iron metabolism; the principles of blood groups and blood transfusions; the principles of coagulation and the pharmacology of coagulation; the role of platelets and pharmacological platelet inhibition; to define thrombophilia and to understand thrombotic events; the role of leukocytes in health and disease; the analysis of blood samples; the principles of hematopoietic stem cell transplantation.
2. The development of the immune system; the structure and function of primary and secondary lymphoid organs; the cellular and molecular mechanisms of the innate and adaptive immune systems; the effector mechanisms of immune responses against pathogens; basic concepts of immune-mediated diseases (allergy and autoimmunity); tumor immunology, immunodeficiency; organ transplantation; basic knowledge of therapies.

Content
1. Introduction to hematopoiesis, hematopoietic growth factors, hematopoietic transcription factors, erythrocytosis, blood groups, blood transfusion, iron metabolism, platelets, coagulation cascade, fibrinolysis, hemoglobin, hemoglobinopathies, leukocytes (granulocytes, monocytes), clinical presentation of neutropenia, pharmacology of hemostasis, clinical presentation of thrombophilia, basics of hematopoietic stem cell transplantation, some aspects of laboratory medicine in hematology, virtual microscopy of blood and bone marrow smears.
2. Structure and anatomical position of primary and secondary lymphoid organs, cells and molecules of the innate immune system, T and B cell development and receptor diversity, major histocompatibility complex (MHC) and antigen presentation, effector B cells and antibodies, effector T cells, regulatory T cells and cytokines, allergy and hypersensitivities, autoimmunity and anti-inflammatory drugs, transplantation and immunosuppressive drugs, immunodeficiency, immune response in cancer and immunotherapies.

Lecture notes
The course is supported by a Moodle page through which students have access to all necessary documentation.

Literature
The essential course material will be available on the course's Moodle Page in the form of lesson handouts. Suggested reference books include:
- Blood: Hoffbrand's Essential Haematology
- Immune system: Herbert Hof, Rüdiger Dörries; unter Mitarbeit von: Gernot Geginat, Dirk Schlüter and Constanze Wendt Medizinische Mikrobiologie Thieme 2017

Prerequisites / notice
The immune system part of this course builds on the content of the "Infection" course.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>377-0301-02L</td>
<td>Nutrition and Digestion</td>
<td>O</td>
<td>5 credits</td>
<td>5V</td>
<td>W. Langhans, L. Käser, C. Stockmann</td>
</tr>
</tbody>
</table>

Abstract
This module imparts basic knowledge about the morphology and function of the digestive system and the importance of nutrition for health. The course is supported by a Moodle page through which students have access to all necessary documentation.

Objective
The aim of this module is that the students know and understand the morphology and function of the digestive system including its associated glands as well as the importance of nutrition for health. In particular, the students shall understand the relationships between food intake and digestion as well absorption and metabolism of particular nutrients. This knowledge shall enable the students to deduct the pathophysiology and pathology of the most important diseases of the digestive system and shall give them an idea of the pertinent diagnostics and therapy.

Prerequisites / notice
Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>377-0301-03L</td>
<td>Endocrinology, Metabolism</td>
<td>O</td>
<td>5 credits</td>
<td>5V</td>
<td>M. Stoffel, F. Beuschlein, A. Hall, C. Wolftrum</td>
</tr>
</tbody>
</table>

Abstract
Discussion of normal structure and function of the endocrine systems, their interaction with the autonomic nervous system and their role in metabolism. In addition, pathophysiological and clinical aspects, diagnostics and therapeutic concepts of the most important endocrine diseases and related metabolic disorders as well as respective preventive measures are addressed.
Upon successful completion of this module, students should:

- be able to explain the systematics of the endocrine system;
- know the structure and function of the hypothalamus, pituitary gland, adrenal gland, endocrine pancreas, thyroid gland, ovaries, testes;
- know the principles and regulation of bone, calcium and phosphate metabolism, energy balance, glucose metabolism, lipid metabolism, blood pressure;
- know the hormonally regulated metabolic processes (carbohydrates, protein and fat);
- know the most important endocrine diseases and tumors, their development, clinic, diagnostics and therapy;
- know the most important measures for the prevention of metabolic diseases and the underlying mechanisms.

In this module, students learn about anatomy, physiology, and pathophysiology of the endocrine glands, as well as the clinical, diagnostic, therapeutic, and preventive aspects of the most important endocrine diseases. This includes:

- Systematics of the endocrine system: structure and anatomical location of the various endocrine glands.
- Neuronal innervation and vascular supply area of the endocrine glands.
- Hormone classes: Protein and polypeptide hormones, amino and amino acid derivatives steroid hormones, biosynthesis of protein and polypeptide hormones, biosynthesis of amino and amino acid derivatives, biosynthesis of steroid hormones, storage of hormones, secretion of hormones, transport of hormones, half-lives, degradation and excretion of hormones.
- Transmission of information by hormones: hormone action at receptors, structure and function of membrane-associated hormone receptors, structure and function of nuclear receptors, regulation of hormone secretion.
- Structure and function of the hypothalamus, structure and function of the pituitary gland.
- Structure and function of the thyroid gland, under- and over-functioning of the thyroid gland, principles of diagnostics and therapy of thyroid diseases.
- Symptoms, medical history and clinical examination of thyroid diseases.
- Bones, calcium and phosphate metabolism.
- Regulation of glucose, lipid and protein metabolism, eating disorders, etiology, diagnostics, therapy and prevention of adipsitas.
- Structure and function of the adrenal gland, pathogenesis, principles of diagnostics and therapy of diseases with hyper- and hypofunction of the adrenal gland.
- Symptoms, anamnesis and clinical examination in case of hyper- and hypofunction of the adrenal gland.
- Structure and function of the ovaries and testes, principles of reproductive physiology.

There is no traditional script for this course. Instead the course is supported by a Moodle page through which students have access to all necessary texts, exercises, videos and activities.

The essential course material will be available on the course’s Moodle Page in the form of scripts and lesson handouts. The course does not have an “official” textbook, but students may find a general reference book on the topic interesting. For this purpose the text “Endokrinologie und Stoffwechsel” von Stefan Fischl and Gatien A. Spinas (Herausgeber), Thieme Verlag, may be helpful.

The course builds on the content of the "Chemie für Mediziner", "Biochemie", "Pathobiochemie", "Pharmakologie für Mediziner" and "Molekulare Genetik und Zellbiologie" course and "Nutrition and Digestion".

### Additional Courses 2nd Year

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>377-0311-00L</td>
<td>Clinical Anatomy Lab</td>
<td>O</td>
<td>5</td>
<td>7P</td>
<td>J. Loffing, O. Ullrich, I. Amrein, G. Colaccio, N. Lier, further lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

Topographical Anatomy and Radioanatomy of the head, skull, central nervous system, neck and neck organs, upper and lower extremities, thoracic and abdominal wall and organs, organs, pelvis and pelvic organs, dorsal muscles, vessels, nerves, functions, clinical aspects.

Methods: Anatomical dissection of human bodies.

**Objective**

Learning and understanding of the detailed composition and function of the healthy human body and its components. Learning of selected examples of relevant radiographic anatomy and their implication in clinical medical work.

**Content**

Topographic – and radiographic anatomy of selected anatomical regions. Students dissect these regions and discuss important clinical content with aid of assistants.

**Prerequisites / notice**

Voraussetzungen:

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Hombodase

### Additional Courses 3rd Year

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>377-0503-01L</td>
<td>Geriatrics</td>
<td>O</td>
<td>1</td>
<td>1V</td>
<td>J. Goldhahn, R. W. Kressig, M. Martin, M. Ristow, further lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

Fundamentals and relevance of the aging process, as well as its biochemical, physiological and evolutionary basis. Insights into its individual as well as economic impact, including interventional and pharmacological treatment options.
Upon successful completion of the module, students should be able to
1. correctly describe the biological bases of the aging process;
2. derive physical and pharmacological choices to modulate the aging process;
3. understand the social and psychological implication of aging;
4. describe the specificities of geriatric medicine in the stationary setting;
5. identify the age-specific differences in both diagnostics and therapeutics.

Abstract

Fundamentals and relevance of the aging process, as well as its biochemical, physiological and evolutionary basis. Insights into its individual as well as economic impact, including interventional and pharmacological treatment options.

Prerequisites / Prerequisites:

notice

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Hämodynamik
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

Abstract

The module Paediatrics describes the peculiarities of the paediatric anamnesis as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart and the most common respiratory diseases are described throughout the different age stages.

Objective

• Knowledge of the paediatric aspects of the medical history
• Knowledge of the enormous variety of child development (inter- and intra-individual variability)
• Milestone concept: Assessment of the stage of development of a child in the first years of life
• Landmark concept: first knowledge of the demilisation on normality versus disorder
• Getting to know frequent developmental pediatric disorders
• Knowledge of the most common congenital heart defects
• Getting to know and recognize respiratory diseases of the upper and lower respiratory tract
• Landmark concept: first knowledge of the demilisation on normality versus disorder
• Getting to know frequent developmental pediatric disorders
• Knowledge of the most common congenital heart defects
• Getting to know and recognize respiratory diseases of the upper and lower respiratory tract

Content

It describes the peculiarities of the pediatric anamnesis as well as selected topics of the healthy and sick child. The focus is on the newborn, development in the first years of life and adolescence. Infections, congenital heart, and the most common respiratory diseases are described throughout the different age stages.

Prerequisites / notice

Prerequisites:

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
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LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

Abstract

By focusing on the 20 most frequent emergencies, the students will learn how to make quick decisions including diagnostic strategy and therapeutic measures. In practical exercises the students practice interprofessional aspects and discuss legal and ethical questions of emergency medicine.
Objective
Perform a triage based on the assessment of the vital signs.
Collect a targeted anamnesis (max. 5-6 questions) of a patient and/or family member
Determine the status of a patient with the necessary clinical examinations.
Determine a differential diagnosis based on the targeted anamnesis and the status.
Interpret the vital signs of a patient
Interpret the results of the paraclinical examinations and confirm/reject the differential diagnosis.
Based on the differential diagnosis, determine the necessary paraclinical examinations
Determine the next steps (treatment in hospital / by family doctor / immediate measures)
Identify possible therapeutic measures

Content
Mornings – case discussions & lectures entire group:
• Hypo / Hyperglycemia
• Principles of poisoning
• Acute Dyspnoea
• Cough
• Acute Diarhoea
• Gastrointestinal bleeding
• Acute Kidney injury
• Hypertensive Crisis
• Acute Headache
• Coma
• Chest Pain
• Syncope
• Acute Abdominal pain
• Acute blood loss
• Common Trauma
• Head Trauma
• Fever in child
• Crying child
• Seizures and convulsions
• Dyspnoea in child

Afternoon – 4 smaller groups rotating:
• Emergency room (Hospital Lugano)
• Emergency call-center / Ambulance (Croce Verde - Lugano)
• Simulation center (Lugano)
• Case discussion (Bellinzona)
• BLS Refresh

Prerequisites / notice
Voraussetzungen:
LE 377-0101-00L Grundbausteine Mensch
LE 377-0211-00L Körperliche Untersuchung
LE 377-0411-00L Internistische Untersuchung
alle Organsysteme des 1.-4. Semesters

377-0509-00L Pathology
Only for Human Medicine BSc
Objectives
After successfully completing the «General Pathology» module, students should be able to
1. to describe the goals and methods of pathoanatomical diagnostics and in reference to clinical practice.
2. to name the general causes and mechanisms of disease development and the associated pathomorphological changes in cells and tissues.
3. to fundamentally link the general causes and mechanisms of disease development with the therapeutic approaches that arise from them.
4. to describe the mechanisms of general inflammation, cell damage and circulatory pathology and relate them to the pathogenesis of specific diseases.
5. to explain the basics of the classification of benign and malignant tumors.
6. to describe the value of pathoanatomical and molecular diagnostics for the predictive and prognostic stratification of patients and to fundamentally relate them to clinical therapy decisions.

After successfully completing the «Surgical Pathology» module, students should be able to
1. to name the most important organ-specific diseases of the nervous system, the endocrine system, the cardiovascular system, the respiratory system, the digestive system, the urogenital system, the musculoskeletal system and the skin and to describe their characteristic macroscopic and microscopic manifestations.
2. to relate the etiology and pathogenesis of the most important organ-specific diseases to their morphological appearance and clinical presentation.
3. to describe the etiopathogenesis of the most important organ-specific diseases and to understand the relation to the mode of action of common therapeutic approaches.
4. to describe the fundamental importance of pathology and molecular diagnostics for personalized medicine and to describe specific application examples.
The students develop the basics of medical law, clinical ethics and communication needed for central applications in the clinic. They learn

- the importance of patient care by combining patient and interprofessional perspectives as well as the cooperation with other healthcare professions, at any moment (out- and inpatient treatment) as the patient progress along a care pathway.

- Students actively participate in interprofessional sessions, are open to other viewpoints, and consider these for the care and safety of the patients.

- The students are able to analyze an interprofessional patient-path and modify it according to the personal patient situation.

- The students are able to take different perspectives (patient, family etc.) and consider them while planning a patient-path.

- Students deal with other health professionals and together plan an appropriate patient-path.

After passing the module successfully, students should be able to

- Understand the concept and needs of vulnerable patients and address the concept ethically, legally and communicate adequately

- Know about the necessity of interprofessional collaboration in the process of dealing with ethically and juridically complex cases and practice first steps.

- Understand and describe the connections of ethics, law and communication and reflect on the implementation in clinical practice

- Know about ethical and legal basics of diagnostics and therapy and how these principles are put into practice

- Know about the relation to pathophysiology, symptomatology and medical diagnostics. We establish clinical references by broadcasting the mortality conference at the USZ. An integrated revision course and exercises based on PathoMaps offer you the opportunity to link the subject matter of the lecture with already known contents, to structure it further and to clarify open points together. A special lecture on molecular pathology, digital pathology and bioinformatics will introduce you to future technologies that are of particular importance for modern medicine.

The special pathology part covers the main topics:

1. upper and lower respiratory tract
2. 2nd upper gastrointestinal tract
3. lower gastrointestinal tract
4. liver, gall bladder, pancreas
5. kidney, draining urinary tract
6. male sexual organs, prostate
7. future technologies (molecular pathology, digital pathology, bioinformatics)
8. blood and bone marrow, lymphatic system
9. endocrine organs
10. skin, bones, joints, soft tissue
11. female sexual organs, mamma
12. neuropathology

Prerequisites / notice

LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Hombostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

<table>
<thead>
<tr>
<th>377-0513-00L</th>
<th>Ethics and Legal Aspects and Communication</th>
<th>O</th>
<th>4 credits</th>
<th>2G</th>
<th>S. Goldhahn, T. Krones, B. Tag</th>
</tr>
</thead>
</table>

Abstract

The students develop the basics of medical law, clinical ethics and communication needed for central applications in the clinic. They learn

- how relevant legal framework conditions are to be observed in everyday clinical practice and how, in communication with patients, the principles of self-determination, patient well-being and damage avoidance are practically implemented.

- Know about the concept of evidence-based decision aids

- Apply the concept of evidence based decision aids

- Apply the concept of evidence-based decision aids

- Understand and describe the connections of ethics, law and communication and reflect on the implementation in clinical practice

- Know about the necessity of interprofessional collaboration in the process of dealing with ethically and juridically complex cases and practice first steps.

- Know about the relation to pathophysiology, symptomatology and medical diagnostics. We establish clinical references by broadcasting the mortality conference at the USZ. An integrated revision course and exercises based on PathoMaps offer you the opportunity to link the subject matter of the lecture with already known contents, to structure it further and to clarify open points together. A special lecture on molecular pathology, digital pathology and bioinformatics will introduce you to future technologies that are of particular importance for modern medicine.

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The students develop the basics of medical law, clinical ethics and communication needed for central applications in the clinic. They learn

- the importance of patient care by combining patient and interprofessional perspectives as well as the cooperation with other healthcare professions, at any moment (out- and inpatient treatment) as the patient progress along a care pathway.

- Students actively participate in interprofessional sessions, are open to other viewpoints, and consider these for the care and safety of the patients.

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- The students are able to take different perspectives (patient, family etc.) and consider them while planning a patient-path.

- Students actively participate in interprofessional sessions, are open to other viewpoints, and consider these for the care and safety of the patients.
Content
Based on various patient situations, students learn how an interprofessional patient-path looks like. During the self-study time, the students bring “their own patient” from their private environment and accompany her/him during the patient-path. Within this framework, the individual path including all health professionals involved, will be analyzed. An exemplary patient case follows each session of the modules, to align the theoretical inputs with the corresponding patient case. The students have the opportunity to visit a rural hospital in another canton and become acquainted with the importance of the free choice of doctors.

Prerequisites / notice
Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
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LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nierensystem
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorganen
LE 377-0403-00L Haut und Anhangsorganen

377-0501-00L Reproduction
Only for Human Medicine BSc
O 4 credits 5V
P. Imesch, G. Hasenberg, B. Leeners, C. Maake, R. Messmer, N. Ochsenbein-Kölble

Abstract
In this module we lay the anatomical and physiological foundations for the subject of “reproduction”. The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and goes from the normal cycle of the woman and her disorders to the pregnancy and related issues to the obstetrics.

Objective
• Anatomy
  o Knowledge of the function of the female and male sexual organs
  o Explaining the development of the maternal and fetal parts of the placenta
  o Explaining the anatomy of the pelvis and the pelvic floor
• Gynecology
  o Recognizing gynecological emergencies
  o Listing of the various types of bleeding and irregularities
  o Overview of the benign tumors of the uterus and ovaries as well as the malignant tumors of the cervix and the endometrium
• Reproductive Endocrinology
  o Outlining of the main regulatory hormones of the female cycle and explaining their effects
  o Listing of the most important sterility factors
  o Discussing the main contraceptive methods with their mechanisms of action and contraceptive safety
• Physiological situations in obstetrics
  o Knowledge of the physiological processes and adaptation processes during pregnancy
  o Determination of birth process
  o Being aware of the meaning of the puerperium

Content
This module gives the anatomical and physiological foundations for the subject of "reproduction". The associated clinical challenges are conveyed from different points of view and with different actors. The content is chronologically prepared and shows the normal female cycle and her disorders as well as the pregnancy and related issues to the obstetrics. Students will have the opportunity to work with prospective midwives to learn basic skills of normal birth through a simulation.

Prerequisites / notice
Voraussetzungen:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
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LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorganen
LE 377-0403-00L Haut und Anhangsorganen

377-0517-00L Oncology
Only for Human Medicine BSc
O 2 credits 2V
A. Alimonti, A. Calcinotto, A. Fontecedro-Curioni, A. Stathis, J.-P. Theurillat

Abstract
Advances in our knowledge of cancer genetic and the cancer immunology are changing the ways by which clinicians treat various types of cancer. This is a unique course designed to help students to learn about cutting-edge principles of cancer genetic, cancer immunology and target therapy and to apply these concepts to the clinical practice guided by leading experts in the field.

Objective
Students will learn basic concepts of cancer patients’ management and will acquired knowledge regarding experimental and clinically approved anti-cancer therapies.
Content

Basic knowledge in oncology
1. The cancer outbreak and its prevention
2. Tumor diagnostic, imaging and screening
3. Basic principle of cancer management and tumor recurrence
4. Clinical application: a clinical case study

Experimental immuno-oncology
1. Hallmarks of Cancer
2. The promise of Immuno-oncology
3. Experimental Immunotherapies: Checkpoint Blockade and CAR T cells
4. From Bedside to Bench to Bedside (Journal Club)

Targeted therapy
1. Cancer Genomics and Epigenomics
2. Basic knowledge of signal transduction and cancer metabolism
3. From Arsenic Trioxide and Glivec to modern targeted therapies
4. Mechanism of resistance to targeted therapies

Oncology practice
1. Basic and clinical application: Chemotherapy
2. Basic and clinical application: Radiotherapy
3. Clinical application: Evidence Based Medicine in oncology
4. Design and analysis of Clinical Trial
5. Clinical application: Immunotherapy
6. Clinical application: Target Therapy
7. From Symptoms to diagnosis
8. Oncology Emergency

Prerequisites / notice
Prerequisites:
LE 377-0105-00L Bewegungsapparat
LE 377-0107-00L Nervensystem
LE 377-0201-00L Herz-Kreislauf-System
LE 377-0203-00L Atmungs-System
LE 377-0205-00L Nieren und Homöostase
LE 377-0301-01L Blut, Immunsystem
LE 377-0301-02L Ernährung und Verdauung
LE 377-0301-03L Endokrinologie, Stoffwechsel
LE 377-0401-00L Sinnesorgane
LE 377-0403-00L Haut und Anhangsorgane

377-0519-00L Ultrasound Basics
O 1 credit 1P M. Rominger

Only for Human Medicine BSc

Abstract
Zurich Ultrasound-Modell (ETH/SGUM/UZH) for ultrasound profiles (curricular) und SGUM certificate basic course abdomen during medical studies (SGUM-Young Sonographers, facultative) with E-Learning and 8 hours practical teaching with 4 students per machine and instructor (curricular), as well as facultative 8 more hours practice and OSCE in the following semester.

Objective
Ultrasound basics
• Understanding of basic ultrasound physics.
• Basic ultrasound anatomy abdomen.
• To know and to do a typical Abdomen and soft-tissue ultrasound examination.
• Classical ultrasound pathology (Ascites, pleural effusion, gallstones, urinary retention …).
• Know the most important artefacts and relevance for ultrasound imaging.
• SGUM basic abdomen certificate sucessful determination

Content
Modules curricular teaching ETHZ
- 1+2 Anatomy
- 3+4 Liver, biliary tract, pleura, rips, lung
- 5+6 Pankreas, spleen, adrenals, abdominal vessels
- 7+8 kidneys, bladder, neck, lymphnodes, FAST
SGUM – Young Sonographers (facultative in the 6th Semester BSc Human Medicine)
- 9+10
- 10+11
- 11+12
- 13+14

Prerequisites / notice
Ultracshall Theorie

Voraussetzung:
LE 377-0311-00L Praktikum klinische Anatomie

Courses in Medical Sciences
Core Courses 2nd Year

Number Title Type ECTS Hours Lecturers
401-0683-00L Statistics II O 3 credits 2V+1U D. Stekhoven

Abstract
Extension of statistics for medical students. This lecture is based on the content of Statistics I. The focus will be on the understanding and the concrete application of statistical methods, as they are used in medical research. Exercises will be solved using the statistical programming environment R.

Objective
After this course you will understand the concept of a broad selection of statistical methods (see also Content). Furthermore, you will know when to use which method. Especially, you will be able to read, understand, and scrutinise the results from such methods, whether these results are written or graphical.

Using the statistical programming environment R, you will be able to read in data, analyse them in various ways, visualise and publish the results in reports or presentations. Knowing R will also enable you to reproduce published analyses, to check whether they work or to use them for your own medical research questions.
The course will cover the following topics.
For the part on regression: simple linear regression; multiple regression (including factors and interactions); model selection; logistic regression (including odds ratio and their interpretation); Bayes inference.
For the part on data: categorical data (including univariate tests); power analysis (including a guide on writing an ethics proposal); dealing with missing values.
For the part on further methods: supervised vs unsupervised learning; dimensional reduction (including PCA and tSNE); survival analysis (including Kaplan-Meier curves and logrank test).

This lecture gives an introduction to programming in Python and an overview of basic problem solving strategies and design principles for efficient algorithms and data structures.

The course enables students to:
- interpret measurements of physiological signals and analyze these for noise contributions
- explain the fundamentals of data acquisition, signal processing and controls engineering
- interpret measurements of physiological signals and analyze these for noise contributions
- acquire practical experience with sensors/signals, actuators, signal processing, controls engineering as well as 3D design/printing
- describe the user-centered design and evaluation process of a medical engineering system
- describe the user-centered design and evaluation process of a medical engineering system
- acquire practical experience with sensors/signals, actuators, signal processing, controls engineering as well as 3D design/printing

The course will guide students through the user-centered development and evaluation process of a medical engineering system for arm movement support. It will introduce the fundamentals of data acquisition, signal processing and control engineering, complemented by hands-on experience with sensors/signals, actuators, signal processing, feedforward/feedback control as well as 3D design/printing.

The course will cover the interdisciplinary elements of a medical engineering development and its evaluation, ranging from human factors to sensor and actuator technologies, (real-time) signal processing, control engineering basics as well as safety/ethical aspects. It is framed around the electrophysiological assessment and robotic movement support following spinal cord injury, and complemented with practical training on a didactic elbow exoskeleton.

The main focus lies on general-purpose design techniques for efficient algorithms, such as the greedy method, dynamic programming, or the divide and conquer strategy. These techniques are demonstrated with many examples from practice.

Here are the details of the course:

### Core Courses 3rd Year

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>252-0866-00L</td>
<td>Foundations of Computer Science for Human Medicine</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>H.-J. Böckenhauer, D. Komm, M. Dahinden</td>
</tr>
<tr>
<td>377-0523-00L</td>
<td>Medical Technology I</td>
<td>O</td>
<td>3 credits</td>
<td>4G</td>
<td>R. Gassert, O. Lambercy</td>
</tr>
</tbody>
</table>

### Compensatory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>376-1103-00L</td>
<td>Frontiers in Nanotechnology</td>
<td>W</td>
<td>4 credits</td>
<td>4V</td>
<td>V. Vogel, further lecturers</td>
</tr>
</tbody>
</table>
Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>4</td>
<td>3V</td>
<td>K. Maniura, M. Rottmar, M. Zenobi-Wong</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The course covers the following topics: 1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials. 2. The concept of biocompatibility. 3. Introduction into methodology used in biomaterials research and application. 4. Introduction to different material classes in use for medical applications.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed. A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>Handouts are deposited online (moodle).</td>
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<tbody>
<tr>
<td>376-1651-00L</td>
<td>Clinical and Movement Biomechanics</td>
<td>4</td>
<td>3G</td>
<td>N. Singh, R. List, P. Schütz</td>
</tr>
<tr>
<td>Abstract</td>
<td>Number of participants limited to 50.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>This course includes study design, measurement techniques, clinical testing, accessing movement data and anysis as well as modeling with regards to human movement.</td>
<td></td>
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<tr>
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<td>Handouts and references therein.</td>
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<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0022-00L</td>
<td>Computer-Assisted Drug Design</td>
<td>1</td>
<td>1V</td>
<td>S. Riniker, G. Landrum</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.</td>
<td></td>
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<tr>
<td>Content</td>
<td>The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).</td>
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<tr>
<td>Lecture notes</td>
<td>Script will be available.</td>
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<table>
<thead>
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<th>ECTS</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0250-00L</td>
<td>Biotransformation of Drugs and Xenobiotics</td>
<td>1</td>
<td>1V</td>
<td>S.-D. Krämer</td>
</tr>
<tr>
<td>Abstract</td>
<td>Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.</td>
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<tr>
<td>Content</td>
<td>Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Toxic reactions of metabolites. Factors which affect the biotransformation.</td>
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<td></td>
</tr>
</tbody>
</table>

Literature

Recommended textbooks:

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1238 of 2416
535-0310-00L Glycobiology in Drug Development

Abstract
Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.

Objective
Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:
- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
- the major types of protein-linked glycans and the biosynthetic pathways for their formation
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

Students gain the ability to reflect on roles of glycosylation in various biological contexts.

Content
lecture plan:
1. Glycans - information carriers in biology and pharmacotherapy
2. Glucocerebrosidase and the biosynthesis of N-glycans
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
5. Production and gCQA analysis of Glucocerebrosidase, monoclonal antibodies, glycoprotein hormone drugs - Glycoanalytics
6. EPO "the same but different"

Lecture notes
The slides used for the lectures will be provided online

Literature
- recent publications as cited/proposed on the lecture slides

Prerequisites / notice
Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>Problem-solving</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td></td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
</tr>
</tbody>
</table>

535-0423-00L Drug Delivery and Drug Targeting

Abstract
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective
The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature

Further references will be provided in the course.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Customer Orientation</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>Creative Thinking</td>
</tr>
</tbody>
</table>

551-0307-00L Molecular and Structural Biology I: Protein Structure and Function

Abstract
D-BIOL students are obliged to take part I and part II (next semester) as a two-semester course

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.
### Literature
Scripts on the individual topics can be found under [http://www.mol.biol.ethz.ch/teaching.](http://www.mol.biol.ethz.ch/teaching)

**Basics:**
- Creighton, T.E., Proteins, Freeman, 1993

Current topics: References will be given during the lectures.

### 551-0309-00L Concepts in Modern Genetics

**Information for UZH students:** Enrolment to this course unit only possible at ETH. No enrolment to module BIOC348 at UZH.

**Please mind the ETH enrolment deadlines for UZH students:** [https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html](https://www.ethz.ch/en/studies/non-degree-courses/special-students/university-of-zurich.html)

**Abstract**
Concepts of modern genetics and genomics, including principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Objective**
This course focuses on the concepts of classical and modern genetics and genomics.

**Content**
The topics include principles of classical genetics; yeast genetics; gene mapping; forward and reverse genetics; structure and function of eukaryotic chromosomes; molecular mechanisms and regulation of transcription, replication, DNA-repair and recombination; analysis of developmental processes; epigenetics and RNA interference.

**Lecture notes**
Scripts and additional material will be provided during the semester.

### 551-0313-00L Microbiology (Part I)

**Abstract**
Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Objective**
This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover the current research on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Content**
Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

**Lecture notes**
Updated handouts will be provided during the class.

**Current literature references**
Will be provided during the lectures.

**Prerequisites / notice**
English
The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

### 551-0319-00L Cellular Biochemistry (Part I)

**Abstract**
Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

**Objective**
The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signalling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to describe the relevance of particular signaling pathways for cellular pathologies such as cancer.

**Content**
Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

**Literature**
Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

### 701-2413-00L Evolutionary Genetics

**Abstract**
The concept course 'Evolutionary Genetics' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

**Objective**
The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

**Content**
Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher’s fundamental theorem.

Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

**Lecture notes**
Handouts

**Literature**

### 752-4009-00L Molecular Biology of Foodborne Pathogens

**Abstract**
The concept course 'Molecular Biology of Foodborne Pathogens' consists of two lectures that jointly provide an introduction to the fields of population and quantitative genetics (emphasis on basic concepts) and ecological genetics (more emphasis on evolutionary and ecological processes of adaptation and speciation).

**Objective**
The aim of the course is to provide students with a solid introduction to the fields of population genetics, quantitative genetics, and ecological genetics. The concepts and research methods developed in these fields have undergone profound transformations; they are of fundamental importance in our understanding of evolutionary processes, both past and present. Students should gain an appreciation for the concepts, methods and explanatory power of evolutionary genetics.

**Content**
Population genetics - Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Quantitative genetics - Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossbreeding, effects on fitness; Fisher’s fundamental theorem.

Ecological Genetics - Concepts and methods for the study of genetic variation and its role in adaptation, reproductive isolation, hybridization and speciation.

**Prerequisites / notice**
To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

**Literature**
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.
- Creighton, T.E., Proteins, Freeman, 1993
Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-5103-00L Functional Microorganisms in Foods

Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: anti fungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.

- Legal and protection issues related to functional foods

- Industrial biotechnology of flavor and taste development

- Safety of food cultures and probiotics

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Lecture notes
Copy of the power point slides from lectures will be provided.

Literature
A list of topics for group projects will be supplied, with key references for each topic.

Prerequisites / notice
This lecture requires strong basics in microbiology.

Human Medicine Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>O</th>
<th>W+</th>
<th>W</th>
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<td>O</td>
<td>Compulsory</td>
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<td></td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td></td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
<thead>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
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<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
This course provides the basics of relational databases from the perspective of the user. We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logics

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
The course covers the foundations of design and analysis of algorithms and data structures, including graph theory and graph problems. It also introduces generic and parallel programming.

**Objective**
Understanding design, analysis and implementation of fundamental algorithms and data structures. Overview of the concepts of generic and parallel programming. Hands-on experience with implementing the aforementioned in C++.

**Content**
- Asymptotic runtime (algorithmic complexity)
- Fundamental algorithmic problems, e.g. searching, sorting, shortest paths, spanning trees
- Classical data structures, e.g. search trees, balanced trees, heaps, hash tables
- Graph theory and graph problems
- Problem solving strategies as design patterns for algorithms, e.g. induction, divide and conquer, backtracking, dynamic programming
- Generic programming: C++ templates higher-order functions, lambdas, closures
- Parallel programming: (in)dependence of computations, parallelism and concurrency, shared memory, races, mutual exclusion, communication and synchronisation

**Lecture notes**
Knowledge obtained in the lecture is deepened through practical and/or programming exercises (C++, Code Expert).

**Literature**
- B. Stroustrup, A Tour of C++, 3rd Edition, Addison-Wesley, 2022

**Prerequisite**
Prerequisite: Computer Science I
The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Objective
Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

Content
The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture notes
English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.

Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000

Prerequisites / notice
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.
The general goal of the course consists in presenting ways to teach fundamentals of computer science, which are closely related to contents and methods of mathematics. After attending the course unit, a mathematics teacher is able to teach selected fundamentals of computer science in mathematics classes.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

The main topics of the course unit “Computer Science in Secondary School Mathematics” represent a scientific and didactic added value for mathematics classes.

The course covers the didactics of logic, of cryptography, of finite state automata, of computability and of the introduction to programming. The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

### Content
- The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism, simple dynamic data types are introduced as examples.
- The concepts provided in the course are motivated and illustrated with algorithms and applications.
- The students develop the understanding of fundamental scientific concepts such as algorithm, program, complexity, determinism, computation, automata, verification, testing, security of a cryptosystem and secure communication. They reflect on ways to embed them into a scientifically sound and didactically sustainable mathematics course.
- In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

### Literature

### 252-0856-00L Computer Science

#### Abstract
- The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

#### Objective
- Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

#### Content
- The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism, simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

#### Lecture notes
- English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.

#### Literature
- Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>251-0100-00L</td>
<td>Computer Science Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>2K</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

**Abstract**
Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.

**Objective**
Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department's professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.

**Content**
Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
<td>E-</td>
<td>0 credits</td>
<td>N. Hungerbühler, M. Akveld, D. Grawehr Morath, J. Hromkovic, P. Spindler</td>
</tr>
</tbody>
</table>

**Abstract**
Didactics colloquium

### Computer Science (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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</table>

<table>
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<tr>
<th>V</th>
<th>lecture</th>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The lecture slides are available for download on the course page.

Title: Linear Algebra
Type: O
ECTS: 7 credits
Hours: 4V+2U
Lecturers: Ö. Imamoglu, O. Sorkine Hornung

Abstract: Introduction to linear algebra (vector spaces, linear transformations, matrices), inner product, determinants, matrix decompositions (LU, QR, eigenvalue and singular value decomposition).

Objective:
- Understand and apply fundamental concepts of linear algebra
- Learn applications of linear algebra

Content: Linear Algebra:
Linear systems of equations, vectors and matrices, norms and scalar products, LU decomposition, vector spaces and linear transformations, least squares problems, QR decomposition, determinants, eigenvalues and eigenvectors, singular value decomposition, applications.

Lecture notes: See course website
Literature: Recommendations on the course website
Prerequisites / notice: The relevant high school material is reviewed briefly at the beginning.

Fostered competencies
Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Analytical Competencies
Social Competencies: Communication
Personal Competencies: Adaptability and Flexibility

252-0025-01L Discrete Mathematics
Number: 7 credits
Type: O
ECTS: 7 credits
Hours: 4V+2U
Lecturers: U. Maurer

Abstract: Content: Mathematical reasoning and proofs, abstraction, Sets, relations (e.g. equivalence and order relations), functions, (un-)countability, number theory, algebra (groups, rings, fields, polynomials, subalgebras, morphisms), logic (propositional and predicate logic, proof calculi).

Objective: The primary goals of this course are (1) to introduce the most important concepts of discrete mathematics, (2) to understand and appreciate the role of abstraction and mathematical proofs, and (3) to discuss a number of applications, e.g. in cryptography, coding theory, and algorithm theory.

Content: See course description.
Lecture notes: available (in English)

252-0027-00L Introduction to Programming
Number: 7 credits
Type: O
ECTS: 7 credits
Hours: 4V+2U
Lecturers: T. Gross

Abstract: Introduction to fundamental concepts of modern programming and operational skills for developing high-quality programs, including large programs as in industry. The course introduces software engineering principles with an object-oriented approach based.

Objective: Many people can write programs. The "Introduction to Programming" course goes beyond that basic goal: it teaches the fundamental concepts and skills necessary to perform programming at a professional level. As a result of successfully completing the course, students master the fundamental control structures, data structures, reasoning patterns and programming language mechanisms characterizing modern programming, as well as the fundamental rules of producing high-quality software. They have the necessary programming background for later courses introducing programming skills in specialized application areas.

Content: Basics of object-oriented programming. Objects and classes. Pre- and postconditions, class invariants, design by contract. Fundamental control structures. Assignment and references. Fundamental data structures and algorithms. Recursion, Inheritance and interfaces, basic concepts of Software Engineering such as the software process, specification and documentation, debugging, reuse and quality assurance.

Lecture notes: The lecture slides are available for download on the course page.
Literature: See the course page for up-to-date information.
Prerequisites / notice: There are no special prerequisites. Students are expected to enroll in the other courses offered to first-year students of computer science.

252-0026-00L Algorithms and Data Structures
Number: 7 credits
Type: O
ECTS: 7 credits
Hours: 3V+2U+1A
Lecturers: M. Püschel, D. Steurer

Abstract: The course provides the foundation of the design and analysis of algorithms. The material is introduced using classical algorithmic problems including graph problems. The necessary basic introduction to graph theory is provided as part of this course.

Objective: An understanding of the design and analysis of fundamental algorithms and data structures. A basic understanding of graph theory and several basic graph algorithms.

Content: This course is an introduction into the design and analysis of algorithms. On the one hand this includes classical algorithm design patterns including induction, divide-and-conquer and dynamic programming. We study these using classical example such as searching and sorting. On the other hand the course covers the interaction between algorithms and data structures including linked lists, search trees, heaps, and union-find structures. A particular focus are graph algorithms for shortest path and minimal spanning tree problems. We provide the necessary introduction into graph theory as part of this course.

Lecture notes: A complete script in German is under development. A complete draft is already available on the course website.
Abgesehen vom Skript und Vorlesungsunterlagen empfehlen wir die folgenden Bücher als zusätzliches Nachschlagewerk.


First Year Examination Block 2
Offered in the spring semester.

Basic Courses

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0057-00L</td>
<td>Theoretical Computer Science</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>J. Hromkovic, H.-J. Böckenhauer, D. Komm</td>
</tr>
</tbody>
</table>

Abstract

Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be useful? d) What is nondeterminism and what role does it play in CS? e) How to represent infinite objects by finite automata and grammars?

Objective

Learning the basic concepts of computer science along their historical development

Content

This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:

- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

Lecture notes

The lecture is covered in detail by the textbook "Theoretical Computer Science".

Basic literature:


Further reading:


More exercises and examples in:

6. A. Asteroth, Ch. Baier: Theoretische Informatik

Prerequisites / notice

During the semester, two non-obligatory test exams will be offered.

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<th>Number</th>
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<tbody>
<tr>
<td>252-0061-00L</td>
<td>Systems Programming and Computer Architecture</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>T. Roscoe, A. Klimovic</td>
</tr>
</tbody>
</table>

Abstract

Introduction to systems programming, C and assembly language, floating point arithmetic, basic translation of C into assembler, compiler optimizations, manual optimizations. How hardware features like superscalar architecture, exceptions and interrupts, caches, virtual memory, multicore processors, devices, and memory systems function and affect correctness, performance, and optimization.

Objective

The course objectives are for students to:

1. Develop a deep understanding of, and intuition about, the execution of all the layers (compiler, runtime, OS, etc.) between programs in high-level languages and the underlying hardware: the impact of compiler decisions, the role of the operating system, the effects of hardware on code performance and scalability, etc.

2. Be able to write correct, efficient programs on modern hardware, not only in C but high-level languages as well.

3. Understand Systems Programming as a complement to other disciplines within Computer Science and other forms of software development.

This course does not cover how to design or build a processor or computer.
This course provides an overview of "computers" as a platform for the execution of (compiled) computer programs. This course provides a programmer's view of how computer systems execute programs, store information, and communicate. The course introduces the major computer architecture structures that have direct influence on the execution of programs (processors with registers, caches, other levels of the memory hierarchy, supervisor/kernel mode, and I/O structures) and covers implementation and representation issues only to the extend that they are necessary to understand the structure and operation of a computer system.

The course attempts to expose students to the practical issues that affect performance, portability, security, robustness, and extensibility. This course provides a foundation for subsequent courses on operating systems, networks, compilers and many other courses that require an understanding of the system-level issues. Topics covered include: machine-level code and its generation by optimizing compilers, address translation, input and output, trap/event handlers, performance evaluation and optimization (with a focus on the practical aspects of data collection and analysis).

Lecture notes
- C programming
- Integers
- Pointers and dynamic memory allocation
- Basic computer architecture
- Compiling C control flow and data structures
- Code vulnerabilities
- Implementing memory allocation
- Linking
- Floating point
- Optimizing compilers
- Architecture and optimization
- Caches
- Exceptions
- Virtual memory
- Multicore
- Devices

Literature
The course is based in part on "Computer Systems: A Programmer's Perspective" (3rd Edition) by R. Bryant and D. O'Hallaron, with additional material.

Prerequisites / notice
252-0029-00L Parallel Programming
252-0028-00L Design of Digital Circuits

401-0213-16L Analysis II O 5 credits 2V+2U Ö. Imamoglu
Abstract
Differential and Integral calculus in many variables, vector analysis.

Literature
Für allgemeine Informationen, sehen Sie bitte die Webseite der Vorlesung

401-0663-00L Numerical Methods for Computer Science O 7 credits 2V+2U+2P R. Hiptmair
Abstract
The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently
First two weeks: A gentle introduction to C++

1. Computing with Matrices and Vectors
   1.1 Fundamentals
   1.2 Software and Libraries
   1.4 Computational Effort
   1.5 Machine Arithmetic and Consequences

2. Direct Methods for (Square) Linear Systems of Equations
   2.1 Introduction: Linear Systems of Equations
   2.3 Gaussian Elimination
   2.6 Exploiting Structure when Solving Linear Systems
   2.7 Sparse Linear Systems

3. Direct Methods for Linear Least Squares Problems
   3.1 Least Squares Solution Concepts
   3.2 Normal Equation Methods
   3.3 Orthogonal Transformation Methods
   3.3.1 Transformation Idea
   3.3.2 Orthogonal/Unitary Matrices
   3.3.3 QR-Decomposition
   3.3.4 QR-Based Solver for Linear Least Squares Problems

4. Filtering Algorithms
   4.1 Filters and Convolutions
   4.2 Discrete Fourier Transform (DFT)
   4.3 Fast Fourier Transform (FFT)

5. Machine Learning of One-Dimensional Data
   (Data Interpolation and Data Fitting in 1D)
   5.1 Abstract Interpolation (AI)
   5.2 Global Polynomial Interpolation

8. Iterative Methods for Non-Linear Systems of Equations
   8.1 Introduction
   8.2 Iterative Methods
   8.3 Fixed-Point Iterations
   8.4 Finding Zeros of Scalar Functions
   8.5 Newton's Method in R^n
   8.6 Quasi-Newton Method

Lecture notes
Lecture materials (PDF documents and codes) will be made available to the participants through the course web page and online repositories. Access information will be communicated in the beginning of the course.

Literature
M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002
P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves, in case they do not know it already.

Core Courses
Major: Information and Data Processing

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0206-00L</td>
<td>Visual Computing</td>
<td>O</td>
<td>8</td>
<td>4V+3U</td>
<td>M. Gross, M. Pollefeys</td>
</tr>
</tbody>
</table>

Abstract
This course acquaints students with core knowledge in computer graphics, image processing, multimedia and computer vision. Topics include: Graphics pipeline, perception and camera models, transformation, shading, global illumination, texturing, sampling, filtering, image representations, image and video compression, edge detection and optical flow.

Objective
This course provides an in-depth introduction to the core concepts of computer graphics, image processing, multimedia and computer vision. The course forms a basis for the specialization track Visual Computing of the CS master program at ETH.

Content
Course topics will include: Graphics pipeline, perception and color models, camera models, transformations and projection, projections, lighting, shading, global illumination, texturing, sampling theorem, Fourier transforms, image representations, convolution, linear filtering, diffusion, nonlinear filtering, edge detection, optical flow, image and video compression.

In theoretical and practical homework assignments students will learn to apply and implement the presented concepts and algorithms.

Lecture notes
A scriptum will be handed out for a part of the course. Copies of the slides will be available for download. We will also provide a detailed list of references and textbooks.

Literature

Major: Theoretical Computer Science
### Major: Systems and Software Engineering

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>252-0210-00L</td>
<td>Compiler Design</td>
<td>O</td>
<td>8 credits</td>
<td>4V+3U+1A</td>
<td>B. Gärtner, R. Kynig, A. Steger, D. Steurer, E. Welzl</td>
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<td>This course uses compilers as examples to expose students to modern software development techniques. Tentative topics include: compiler organization, lexical analysis, top-down and bottom-up parsing, symbol tables, semantic analysis, code generation, local and global optimization, register allocation, automatic memory management.</td>
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<td>Learn principles of compiler design; gain practical experience designing and implementing a medium-scale software system.</td>
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<td>This course uses compilers as example to expose modern software development techniques. The course introduces the students to the fundamentals of compiler construction. Students will implement a simple yet complete compiler for an object-oriented programming language for a realistic target machine. Students will learn the use of appropriate tools. Throughout the course, students learn to apply their knowledge of theory (automata, grammars, stack machines, program transformation) and well-known programming techniques (module definitions, design patterns, frameworks, software reuse) in a software project.</td>
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<td>A tentative list of topics; compiler organization, lexical analysis, top-down and bottom-up parsing; symbol tables; semantic analysis; code generation; local and global optimization; register allocation; automatic memory management; optional advanced topics if/when time permits.</td>
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<td>Prerequisites / notice</td>
<td>Prior exposure to modern techniques for program construction, knowledge of at least one processor architecture at the assembly language level.</td>
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<tbody>
<tr>
<td>252-0217-00L</td>
<td>Computer Systems</td>
<td>O</td>
<td>8 credits</td>
<td>4V+2U+1A</td>
<td>T. Roscoe, S. Shinde, R. Wattenhofer</td>
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<td>This course is about real computer systems, and the principles on which they are designed and built. We cover both modern OSes and the large-scale distributed systems that power today’s online services. We illustrate the ideas with real-world examples, but emphasize common theoretical results, practical tradeoffs, and design principles that apply across many different scales and technologies.</td>
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<td>The objective of the course is for students to understand the theoretical principles, practical considerations, performance tradeoffs, and engineering techniques on which the software underpinning almost all modern computer systems is based, ranging from single embedded systems-on-chip in mobile phones to large-scale geo-replicated groups of datacenters.</td>
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<td>By the end of the course, students should be able to reason about highly complex, real, operational software systems, applying concepts such as hierarchy, modularity, consistency, durability, availability, fault-tolerance, and replication.</td>
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<td>This course subsumes the topics of both “operating systems” and “distributed systems” into a single coherent picture (reflecting the reality that these disciplines are highly convergent). The focus is system software: the foundations of modern computer systems from mobile phones to the large-scale geo-replicated data centers on which Internet companies like Amazon, Facebook, Google, and Microsoft are based.</td>
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<td>We will cover a range of topics, such as: scheduling, network protocol stacks, multiplexing and demultiplexing, operating system structure, inter-process communication, memory management, file systems, naming, dataflow, data storage, persistence, and durability, computer systems performance, remove procedure call, consensus and agreement, fault tolerance, physical and logical clocks, virtualization, and blockchains.</td>
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<td>The format of the course is a set of about 25 topics, each covered in a lecture. A script will be published online ahead of each lecture, and the latter will consist of an interactive elaboration of the material in the script. There is no book for the course, but we will refer to books and research papers throughout to provide additional background and explanation.</td>
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<td>We will assume knowledge of the &quot;Systems Programming&quot; and &quot;Computer Networks&quot; courses (or equivalent), and their prerequisites, and build upon them.</td>
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### Electives

Students may also choose courses from the Master's program in Computer Science. It is their responsibility to make sure that they meet the requirements and conditions for these courses.

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0293-00L</td>
<td>Wireless Networking and Mobile Computing</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>S. Mangold</td>
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<td>This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.</td>
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<td>The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.</td>
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</table>
Adaptability and Flexibility

The course webpage (look for Stefan Mangold's site)

The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As assessed

The course material will be made available by the lecturer. not assessed

Analytical Competencies

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory assessed

High Performance Computing for Science and Engineering (HPCSE) I

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content

Wireless Communication, Wi-Fi, Contact Tracing, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.

Chapters:
1 Introduction
2 Wireless Communication Basics
3 IEEE 802.11 Wireless LAN (Wi-Fi)
4 IEEE 802.15 Wireless PAN (ZigBee & Bluetooth)
5 Mobile Computing Algorithm Basics: Control and Game Theory
6 Visible Light Communication
7 Audio Communication
8 Cellular Networking Basics (LTE, 5G, Internet-of-Things)
9 Mobile Computing for Automated Medicine Delivery
10 Cognitive Radio, Delay Tolerant Networking, Radio Spectrum Sharing

Lecture notes

The course material will be made available by the lecturer.

Literature

(1) The course webpage (look for Stefan Mangold’s site)
(2) The Java 802 protocol emulator “JEmula802” from https://bitbucket.org/lfield/jemula802

Prerequisites / notice

Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Social Competencies

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

252-3110-00L

Human Computer Interaction

W

6 credits

2V+1U+2A

C. Holz, O. Hilliges

Number of participants limited to 150.

Abstract

The course provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.

Objective

The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context.

Content

The course will introduce students to several methods of analysing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing.

Students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

151-0107-20L

High Performance Computing for Science and Engineering (HPCSE) I

W

4 credits

4G

S. M. Martin, J. H. Walther

Abstract

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

Objective

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed
for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded
system design and includes a series of lab sessions.

Understanding architectures and components, their hardware-software interfaces, the memory architecture, communication between
components, embedded operating systems, real-time scheduling theory, shared resources, low-power and low-energy design as well as
hardware architecture synthesis.

Using the formal models and methods in embedded system design in practical applications using the programming language C, the
operating system ThreadX, a commercial embedded system platform and the associated design environment.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed
for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and
process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things,
as well as mobile devices.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software
interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling,
shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://pbl.ee.ethz.ch/education/embedded-systems.html.

The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at
This course teaches the basics of quantum physics, and complements courses in quantum computation and information theory. Students will be equipped with tools to tackle complex quantum mechanical problems and foundational questions. The course covers approximately the same content as QM1, but from an information-driven perspective.

The course is aimed at non-physicists, and in particular at students with a background in computer science, mathematics or engineering. Basic linear algebra and calculus knowledge is required (equivalent to first-year courses). Therefore complements those courses offered at ETH in both semesters.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

### Prerequisites / notice

Prerequisites: Basic knowledge in computer architectures and programming.

### Literature


### Abstract

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials; channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

### Objective

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monochromatics of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

### Content

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

### Prerequisites / notice

Prerequisites: Basic knowledge in computer architectures and programming.

### Literature

- https://www.cambridge.org/core/books/quantum-processes-systems-and-information/4E459E64E1EE7121CA2321435FAECC8A
- Michael Westmoreland, available at
- W. von der Behrens

### Abstract

This is an introduction to the physics of quantum mechanics, aimed primarily at students with little to no background in physics. We start from the basic postulates and follow an information-theoretical approach to study the behaviour of quantum systems, from a single spin to entangled particles in space and the hydrogen atom.

### Objective

This course teaches the basics of quantum physics, and complements courses in quantum computation and information theory. Students are equipped with tools to tackle complex quantum mechanical problems and foundational questions. The course covers approximately the same content as QM1, but from an information-driven perspective.

### Content

Quantum formalism, from qubits to particles in space; Time and dynamics for quantum systems; Problems in 1D; Uncertainty and open systems; Spin; Problems in 3D; Non-locality and foundational aspects of quantum theory.

### Lecture notes

Lecture notes will be distributed through the semester.

### Literature

Quantum Processes, Systems, and Information, by Benjamin Schumacher and Michael Westmoreland, available at

https://www.cambridge.org/core/books/quantum-processes-systems-and-information/4E459E64E1EE7121CA2321435FAECC8A

### Prerequisites / notice

This course is aimed at non-physicists, and in particular at students with a background in computer science, mathematics or engineering. Basic linear algebra and calculus knowledge is required (equivalent to first-year courses). Physics knowledge is not required. Physicists and students from a different background than outlined above are welcome at their own risk.

Note that while we follow an information-theoretical approach, this is not a course on quantum information theory or quantum computing. It therefore complements those courses offered at ETH in both semesters.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-2300-00L</td>
<td>Neural Networks and Computational Complexity</td>
<td>2</td>
<td>2S</td>
<td>R. Cotterell</td>
</tr>
<tr>
<td></td>
<td>The deadline for deregisters expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<tr>
<td></td>
<td>Objective: The core ideas behind the mathematics of dependency parsing are explored.</td>
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<td></td>
<td>Content: Dependency parsing is a fundamental task in natural language processing. This seminar explores a variety of algorithms for efficient dependency parsing and their derivation in an unified algebraic framework.</td>
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<td></td>
<td>Number of participants limited to 25.</td>
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<tr>
<td>252-2600-05L</td>
<td>Software Engineering Seminar</td>
<td>2</td>
<td>2S</td>
<td>Z. Su, M. Vechev</td>
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<td></td>
<td>The deadline for deregisters expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<td></td>
<td>Objective: The main goals of this seminar are 1) learning how to read and understand a recent research paper in computer science; and 2) learning how to present a technical topic in computer science to an audience of peers.</td>
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<td></td>
<td>Content: Dependency Structures and Lexicalized Grammars: An Algebraic Approach</td>
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<tr>
<td>252-3400-00L</td>
<td>Seminar on Machine Learning Systems</td>
<td>2</td>
<td>2S</td>
<td>A. Klimovic, C. Zhang</td>
</tr>
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<td></td>
<td>The deadline for deregisters expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<td></td>
<td>Objective: This seminar covers core concepts and ideas in the general area of machine learning systems, ranging from distributed and federated learning systems, DevOps systems for ML, life cycle and data management systems for ML, etc. The focus will be to cover fundamental ideas on ML systems, with an emphasis on software systems and platforms.</td>
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<td></td>
<td>Content: The seminar will consist of student presentations based on a list of papers that will be provided at the beginning of the course. Presentations will be done in teams. Presentations will be arranged in slots of 30 minutes talk plus 15 minutes questions. Grades will be assigned based on quality of the presentation, coverage of the topic including material not in the original papers, participation during the seminar, and ability to understand, present, and critique the underlying technology.</td>
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<td></td>
<td>Number of participants limited to 40.</td>
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<tr>
<td>252-3811-00L</td>
<td>Case Studies from Practice Seminar</td>
<td>4</td>
<td>2S</td>
<td>M. Brandis</td>
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<tr>
<td></td>
<td>The deadline for deregisters expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<td></td>
<td>Objective: Participants will learn how to analyze and solve IT problems in practice in a systematic way, present findings to decision bodies, and defend their conclusions.</td>
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<td></td>
<td>Content: Participants understand the different viewpoints for IT-decisions in practice, including technical and business aspects, can effectively analyze IT questions from the different viewpoints and facilitate decision making.</td>
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<td>Number of participants limited to 24.</td>
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<tr>
<td>252-4811-00L</td>
<td>Machine Learning Seminar</td>
<td>2</td>
<td>2S</td>
<td>V. Boeva, T. Hofmann, E. Krymova</td>
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<td></td>
<td>The deadline for deregisters expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<td></td>
<td>Objective: The seminar familiarizes students with advanced and recent ideas in machine learning. Original articles have to be presented, contextualized, and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper.</td>
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<td></td>
<td>Content: The seminar covers a number of recent papers which have emerged as important contributions in the machine learning research community. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications.</td>
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<td></td>
<td>Literature: The papers will be presented and allocated in the first session of the seminar.</td>
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<td></td>
<td>Prerequisites / notice: Successful completion of Lecture &quot;Case Studies from Practice&quot;.</td>
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<td>Number of participants limited to 24.</td>
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<tr>
<td>252-5707-00L</td>
<td>Seminar on Media Innovation</td>
<td>2</td>
<td>2S</td>
<td>S. Kalloori Saikishore, F. Zünd</td>
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<tr>
<td></td>
<td>The deadline for deregisters expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.</td>
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<tr>
<td></td>
<td>Objective: The seminar will cover a number of recent papers which have emerged as important contributions in the machine learning research community. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications.</td>
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<tr>
<td></td>
<td>Literature: The papers will be presented and allocated in the first session of the seminar.</td>
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<td></td>
<td>Prerequisites / notice: Basic knowledge of machine learning as taught in undergraduate courses such as &quot;252-0220-00 Introduction to Machine Learning&quot; are required.</td>
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<td></td>
<td>Number of participants limited to 24.</td>
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</table>
This seminar introduces students to research and innovation in the area of media technology. The media industry is undergoing a fundamental transformation caused by digitalization. Media consumption is shifting away from traditional media such as TV or newspaper towards mobile and delayed consumption. The boundaries between media producers and consumers are getting blurred, and personalized content is increasingly important. Machine learning and AI are crucial tools to help create better content, understand the consumers’ preferences, and surface the essential stories in times of information overload.

This seminar introduces students to the latest research in the field of media technology and innovation. It is an exciting field laying at the intersection of computer vision, computer graphics, natural language processing, and machine learning. The seminar will cover a broad spectrum of topics considering not only the technical innovations but also the possibilities these technologies provide to professionals in the media industry and consumers of media.

227-2211-00L Seminar in Computer Architecture
Number of participants limited to 20.

The deadline for deregistration expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

Abstract
In this seminar course, we will cover fundamental and cutting-edge research papers in computer architecture. The course will consist of multiple components that are aimed at improving students’ technical skills in computer architecture, critical thinking and analysis on computer architecture concepts, as well as technical presentation of concepts and papers in both spoken and written forms.

Objective
The main objective is to learn how to rigorously analyze and present papers and ideas on computer architecture. We will have rigorous presentation and discussion of selected papers during lectures and a written report delivered by each student at the end of the semester. This course is for those interested in computer architecture. Registered students are expected to attend every lecture, participate in the discussion, and create a synthesis report at the end of the course.

Content
Topics will center around computer architecture. We will, for example, discuss papers on hardware security; new execution paradigms like processing in memory; architectural acceleration mechanisms for key applications like machine learning, graph processing and bioinformatics; memory systems; interconnects; various fundamental and emerging paradigms in computer architecture; hardware/software co-design and cooperation; fault tolerance; energy efficiency; heterogeneous and parallel systems; technology scaling; new execution models, etc.

Lecture notes
All the materials will be posted on the course website: https://safari.ethz.ch/architecture_seminar/
Links to past course materials, including the synthesis report assignment, can be found in this page: https://safari.ethz.ch/architecture_seminar

Literature
Key papers and articles, on both fundamentals and cutting-edge topics in computer architecture will be provided and discussed. These will be posted on the course website.

Prerequisites / notice
Design of Digital Circuits.
Students should have done very well in Digital Design and Computer Architecture (https://safari.ethz.ch/digitaltechnik) show a genuine interest in Computer Architecture research and practice.

Minor Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0250-00L</td>
<td>Solving Partial Differential Equations in Parallel on GPUs</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>L. Räss, S. Omlin, M. Werder</td>
</tr>
</tbody>
</table>

Abstract
This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

Objective
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Content
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn about the diffusion process and how to solve it;
- Understand the practical challenges of parallel and distributed computing: (multi-)GPUs, multi-core CPUs;
- Learn about software development tools: git, version control, continuous integration (CI), unit tests.

Part 2 - Developing your own parallel algorithms
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Implement efficient iterative algorithms;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CPUs);
- Learn about main simulation performance limiters.

Part 3 - Final project
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Links to relevant literature will be provided during classes.
Systems Analysis and Mathematical Modeling in Urban Water Management

**Objective**
The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

**Content**
The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:

- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

**Literature**

**Prerequisites**
Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
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</tr>
<tr>
<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Problem-solving</td>
<td></td>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
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<td>Negotiation</td>
<td>Self-direction and Self-management</td>
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</table>

This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.

**Lecture notes**
The handouts in English will be available in digital form.

A list of references is included in the handouts.

**Prerequisites**
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.
Signals and Systems

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.</td>
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</table>

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture notes available on course website.</td>
<td>Control Systems I is helpful but not required.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>151-0575-01L</th>
<th>Signals and Systems</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>A. Carron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Content</td>
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<tr>
<td>Lecture notes</td>
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<table>
<thead>
<tr>
<th>151-0591-00L</th>
<th>Control Systems I</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>E. Frazzoli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: The previous course title in German until HS21 “Regelungstechnik I”.</td>
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<tr>
<td>Abstract</td>
<td>Analysis and controller synthesis for linear time invariant systems with one input and one output signal (SISO); transition matrix; stability; controllability; observability; Laplace transform; transfer functions; transient and steady state responses. PID control; dynamic compensators; Nyquist theorem.</td>
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<tr>
<td>Objective</td>
<td>Identify the role and importance of control systems in everyday life. Obtain models of single-input single-output (SISO) linear time invariant (LTI) dynamical systems. Linearization of nonlinear models. Interpret stability, observability and controllability of linear systems. Describe and associate building blocks of linear systems in time and frequency domain with equations and graphical representations (Bode plot, Nyquist plot, root locus). Design feedback controllers to meet stability and performance requirements for SISO LTI systems. Explain differences between expected and actual control results. Notions of robustness and other nuisances such as discrete time implementation.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture slides and additional material will be posted online.</td>
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<tr>
<td>Literature</td>
<td>There is no required textbook.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Basic knowledge of (complex) analysis and linear algebra.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories. Techniques and Technologies. Analytical Competencies: Decision-making; Media and Digital Technologies; Problem-solving. Project Management. Social Competencies: Communication; Cooperation and Teamwork; Customer Orientation; Leadership and Responsibility; Self-presentation and Social Influence; Sensitivity to Diversity. Personal Competencies: Negotiation; Adaptability and Flexibility; Critical Thinking; Integrity and Work Ethics; Self-awareness and Self-reflection; Self-direction and Self-management.</td>
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<table>
<thead>
<tr>
<th>151-0601-00L</th>
<th>Theory of Robotics and Mechatronics</th>
<th>W</th>
<th>4 credits</th>
<th>3G</th>
<th>to be announced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.</td>
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<tr>
<td>Objective</td>
<td>Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.</td>
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<tr>
<td>Content</td>
<td>An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.</td>
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<tr>
<td>Lecture notes</td>
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<table>
<thead>
<tr>
<th>151-0709-00L</th>
<th>Stochastic Methods for Engineers and Natural Scientists</th>
<th>W</th>
<th>4 credits</th>
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<th>D. W. Meyer-Massetti</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent and subsurface flows. Moreover, mathematical techniques are presented that are used to quantify uncertainty in various engineering applications.</td>
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<td>Objective</td>
<td>By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover, you should be able to develop basic stochastic models of such systems.</td>
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| Data: 01.11.2022 12:41 | Autumn Semester 2022 | Page 1258 of 2416 |
### Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
- Statistical tests for means and goodness-of-fit
All topics are illustrated with engineering applications.

### Lecture notes
Detailed lecture notes will be provided.

### Literature
Some textbooks related to the material covered in the course:

### Fostered competencies

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### Course Descriptions

#### 227-0076-00L Electrical Engineering II

**W 4 credits 2V+2U C. Studer**

**Abstract**
Sinusoidal signals and systems in the time and frequency domain, principle of operation and design of basic analog and digital circuits as well as analog-digital conversion.

**Objective**
see above

**Content**

**Fostered competencies**

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#### 227-0016-00L VLSI 1: HDL Based Design for FPGAs

**W 6 credits 5G F. K. Gürkaynak, L. Benini**

**Abstract**
This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

**Objective**
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

**Content**
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

**Lecture notes**
Textbook and all further documents in English.

**Literature**

**Prerequisites / notice**
- Prerequisites: Basics of digital circuits.
- Examination: In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

**Further details:**
https://isis-students.ee.ethz.ch/lectures/vlsi-i/

#### 227-0731-00L Power Market I - Portfolio and Risk Management

**W 6 credits 4G D. Reichelt, G. A. Koeppe**

**Abstract**
Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1259 of 2416

1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

   2. Market model
      2.1. Market place and organisation
      2.2. Balance groups / balancing energy
      2.3. Ancillary services
      2.4. Market for ancillary services
      2.5. Cross-border trading
      2.6. Capacity auctions

   3. Portfolio and Risk management
      3.1. Portfolio management 1 (introduction)
      3.2. Forward and futures contracts
      3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
      3.4. Risk management 2 (PaR)
      3.5. Contract valuation (HPFC)
      3.6. Portfolio management 2
      2.8. Risk Management 3 (enterprise wide)

   4. Energy & Finance I
      4.1. Options 1 basics
      4.2. Options 2 hedging with options
      4.3. Introduction to derivatives (swaps, cap, floor, collar)
      4.4. Financial modelling of physical assets
      4.5. Trading and hydro power
      4.6. Incentive regulation

Lecture notes
Prerequisites / notice
Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

227-0945-00L Cell and Molecular Biology for Engineers I
W 3 credits 2G to be announced
Does not take place this semester.

Abstract
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes
Scripts of all lectures will be available.

Literature

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227-2037-00L Physical Modelling and Simulation
W 6 credits 4G J. Smajic

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.
Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

The course helps students to successfully take on managerial and entrepreneurial responsibilities in their careers and appreciate the challenges that entrepreneurs and managers deal with.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Throughout small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

All course materials (readings, slides, videos, and worksheets) will be made available to registered course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions, and team work.

Subject-specific Competencies: Concepts and Theories, Analytical Competencies, Problem-solving
Social Competencies: Communication, Self-presentation and Social Influence
Personal Competencies: Creative Thinking, Critical Thinking

Discovering Management (Exercises) is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discovering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of their choice, using your insights from Discovering Management.

All course materials (readings, slides, videos, and worksheets) will be made available to registered course participants through Moodle.

Students have the option to either write this alone or in a group of two students.

Systems Dynamics and Complexity 363-0541-00L

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course, the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.
Abstract
Finding solutions: what is complexity, problem solving cycle.
Implementing solutions: project management, critical path method, quality control feedback loop.
Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption.

Objective
A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

Content
Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.
The course is structured along three main tasks:
1. Finding solutions
2. Implementing solutions
3. Controlling solutions

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. These are provided as homework and two of these will be graded (see "Prerequisites").

Lecture notes
The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

363-1082-00L Enabling Entrepreneurship: From Science to Startup

Students should provide a brief overview (up to 1 page) of their business ideas that they would like to commercialize through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch.

Abstract
This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective
Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea
Content

The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders’ agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Literature

Book
Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

Prerequisites / notice

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

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W 3 credits 2G M. Wörter, M. Beck

Abstract

This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend “Principles of Microeconomics” (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed “Principles of Microeconomics” (LE 363-0503-00L), then you will not be permitted to attend it again.

Objective

The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Content

Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes

Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature


Prerequisites / notice

This course “Einführung in die Mikroökonomie” (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 “Principles of Microeconomics” for Master students.
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:
- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Prerequisites / notice

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.
The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content
- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature
- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

401-0353-00L Analysis 3

Abstract
In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

Objective
The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

Content
1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)
2.) Quasilinear first order PDEs
   - Solution with the method of characteristics
   - Conservation laws
3.) Hyperbolic PDEs
   - wave equation
   - d'Alembert formula in (1+1)-dimensions
   - method of separation of variables
4.) Parabolic PDEs
   - heat equation
   - maximum principle
   - method of separation of variables
5.) Elliptic PDEs
   - Laplace equation
   - maximum principle
   - method of separation of variables
   - variational method

Literature

Prerequisites / notice
Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

401-0625-01L Applied Analysis of Variance and Experimental Design

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

401-4623-00L Time Series Analysis

Abstract
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective
The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARIMA, ARIMA, Introduction into GARCH models

Literature
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice
Basic knowledge in probability and statistics

401-7855-00L Computational Astrophysics (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
### Objective
Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes.

### Content
1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

### Literature
- Galactic Dynamics (Binney & Tremaine, Princeton University Press)
- Computer Simulation using Particles (Hockney & Eastwood CRC press), Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

### Prerequisites / notice
Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Co-ordinator</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0809-00L</td>
<td>Introduction to Computational Physics</td>
<td>8</td>
<td>A. Adelmann</td>
<td>English</td>
</tr>
<tr>
<td>402-1701-00L</td>
<td>Physics I</td>
<td>7</td>
<td>W. Wegscheider</td>
<td>German</td>
</tr>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>6</td>
<td>J. Stelling</td>
<td>English</td>
</tr>
<tr>
<td>651-4241-00L</td>
<td>Numerical Modelling I and II: Theory and Applications</td>
<td>6</td>
<td>T. Gerya</td>
<td>English</td>
</tr>
</tbody>
</table>

### Objective
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

### Content
- Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia.
- Furthermore, an overview of existing software libraries for numerical simulations is presented.

### Literature
- Lecture notes and slides are available online and will be distributed if desired.
- Literature recommendations and references are included in the lecture notes. Lecture and exercise lessons in English, exams in German or in English

### Objective
Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.

<table>
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<td>T. Gerya</td>
<td>English</td>
</tr>
</tbody>
</table>

### Objective
The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.
A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity with stream function/vorticity formulation.


Weeks 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature
The course “Didactic Basics for Student Teaching Assistants” enhance Student Teaching Assistants (Student TAs) to develop knowledge, analytical skills, designing skills, self-competence, and social competence. They are able to structure complex problems systematically using selected methods. They are able to acquire further knowledge and critically analyze the knowledge in interdisciplinary groups and with experts and the help of team tutors.

- Design skills: The students are able to use their knowledge and skills to develop concrete approaches for problem-solving and decision making to a selected problem statement, critically reflect on these approaches, assess their feasibility, to transfer them into a concrete form (physical model, prototypes, strategy paper, etc.) and to present this work in a creative way (role-plays, videos, exhibitions, etc.).

- Self-competence: The students are able to plan their work effectively, efficiently and autonomously. By considering approaches from different disciplines they are able to make a judgment and form a personal opinion. In exchange with non-academic partners from business, politics, administration, non-governmental organisations and media they are able to communicate appropriately, present their results professionally and creatively and convince a critical audience.

- Social competence: The students are able to work in multidisciplinary teams, i.e. they can reflect critically on their own discipline, debate with students from other disciplines and experts in a critical-constructive and respectful way and can relate their own positions to different intellectual approaches. They can assess how far they are able to actively make a contribution to society by using their personal and professional talents and skills as "Change Agents”.

- Remote collaboration competence: The students work in a hybrid setting blending physical and virtual communication and collaboration methods and tools. They experience the potential and limitations of remote collaboration.

The week is mainly about problem-solving and design thinking applied to the complex world of health and well-being. During ETH Week students will have the opportunity to work in small interdisciplinary groups, allowing them to critically analyse both their own approaches and those of other disciplines, and to integrate these into their work.

While deepening their knowledge about sustainable urban development, students will be introduced to various methods and tools for generating creative ideas and understanding how different people are affected by each part of the system. In addition to lectures and literature, students will acquire knowledge via excursions into the real world, empirical observations, and conversations with researchers and experts.

A key attribute of ETH Week is that students are expected to find their own problems, rather than just solve the problem that has been handed to them.

Therefore, the first three days of the week will concentrate on identifying a problem the individual teams will work on, while the last two days are focused on generating solutions and communicating the team’s ideas.

No prerequisites. Programme is open to Bachelor and Masters from all ETH Departments. All students must apply through a competitive application process at www.ethz.ch/ethweek. Participation is subject to successful selection through this competitive process.

### Objective
- Domain-specific knowledge: Students have immersed knowledge about a certain complex, societal topic which will be selected every year. They understand the complex system context of the current topic, by comprehending its scientific, technical, political, social, ecological and economic perspectives.
- Analytical skills: The ETH Week participants are able to structure complex problems systematically using selected methods. They are able to acquire further knowledge and critically analyse the knowledge in interdisciplinary groups and with experts and the help of team tutors.
- Design skills: The students are able to use their knowledge and skills to develop concrete approaches for problem-solving and decision making to a selected problem statement, critically reflect on these approaches, assess their feasibility, to transfer them into a concrete form (physical model, prototypes, strategy paper, etc.) and to present this work in a creative way (role-plays, videos, exhibitions, etc.).
- Self-competence: The students are able to plan their work effectively, efficiently and autonomously. By considering approaches from different disciplines they are able to make a judgment and form a personal opinion. In exchange with non-academic partners from business, politics, administration, non-governmental organisations and media they are able to communicate appropriately, present their results professionally and creatively and convince a critical audience.
- Social competence: The students are able to work in multidisciplinary teams, i.e. they can reflect critically on their own discipline, debate with students from other disciplines and experts in a critical-constructive and respectful way and can relate their own positions to different intellectual approaches. They can assess how far they are able to actively make a contribution to society by using their personal and professional talents and skills as "Change Agents”.

### Content
The week is mainly about problem-solving and design thinking applied to the complex world of health and well-being. During ETH Week students will have the opportunity to work in small interdisciplinary groups, allowing them to critically analyse both their own approaches and those of other disciplines, and to integrate these into their work.

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No prerequisites. Programme is open to Bachelor and Masters from all ETH Departments. All students must apply through a competitive application process at www.ethz.ch/ethweek. Participation is subject to successful selection through this competitive process.

### Prerequisites / notice
- Method-specific Competencies
  - Analytical Competencies assessed
  - Media and Digital Technologies assessed
  - Problem-solving assessed

- Social Competencies
  - Communication assessed
  - Cooperation and Teamwork assessed
  - Sensitivity to Diversity assessed
  - Negotiation assessed

- Personal Competencies
  - Adaptability and Flexibility assessed
  - Critical Thinking assessed
  - Self-direction and Self-management assessed

### Prerequisites / notice
- Self-paced online course: https://moodle-app2.let.ethz.ch/course/view.php?id=17417
- Consolidation Workshops at the beginning of November (dates will be announced in the online course at the beginning of the semester)

### Science in Perspective

#### Didactic Basics for Student Teaching Assistants

**Abstract**
The course “Didactic Basics for Student Teaching Assistants” enhance Student Teaching Assistants (Student TAs) to develop knowledge, capability and confidence to effectively plan and teach courses and exercises. Participants get trained to think critically about students’ learning and create learning situations in which students are actively engaged.

**Objective**
- Reflect on their approach to teaching as well as their attitude towards teaching.
- Understand the basics of teaching and learning in the context of their subject.
- Consciously design the introduction of their course as well as the introduction of single teaching units.
- Apply classroom assessment techniques as formative assessments to measure the current status of their students.
- Develop a didactic concept according to the learning objectives.
- Conduct interactive sequences as learning activities.
- Give and get feedback from peers and self-reflect on their teaching practice.
- Feel confident to use methods for active learning scenarios in their classes.

**Content**
The online course provide a range of relevant topics for developing teaching competences of Student Teaching Assistants:
- Overview about how learning works. Based on these fundamentals of learning participants reflect on their role as Student TAs to feel comfortable in their new role as a teacher.
- Plan an own lesson by introducing a class and locate it in the larger topic (methods: portal and informative introduction).
- Develop learning activities in order to activate students (active learning methods).
- Giving and also getting feedback. The participants integrate this topic also in their lesson plan.

While working through the online course, Student TAs have the chance to reflect, exchange ideas with peers and plan their own teaching accordingly so that they feel confident in their role.

Self-paced online course: https://moodle-app2.let.ethz.ch/course/view.php?id=17417

Consolidation Workshops at the beginning of November (dates will be announced in the online course at the beginning of the semester)
Bachelor’s Thesis

252-0500-00L Bachelor’s Thesis

Abstract
The Bachelor thesis is the final requirement of the BSc program and is supervised by one of the D-INFK professors. The thesis encourages students to show and produce a scientifically structured work.

Objective
In their BSc thesis students should demonstrate their ability to carry out independent, structured scientific work.

Prerequisites / notice
The supervisor of the thesis defines the task, start and end date. A written report will be prepared on the scientific studies carried out, followed by a final presentation. The thesis must be handed in within 6 months.

Computer Science Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

Key for Hours

<table>
<thead>
<tr>
<th>Hour Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
In this class, students will learn concepts and skills for coping with psychosocial demands of teaching. Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Lernformen:

Abstract
This course unit can only be enrolled after successful participation in EW1 (“Human Learning”) and EW2 (“Designing Learning Environments for School”) is recommended, but not a mandatory prerequisite.

Objective
Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.

Prerequisites / notice
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Literature

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1270 of 2416
Abstract

Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective

- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

<table>
<thead>
<tr>
<th>Code</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>272-0101-00L</td>
<td>Subject Didactics of Computer Science I</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>G. Serafini, J. Hromkovic</td>
</tr>
</tbody>
</table>

Abstract

The unit "Subject Didactics of Computer Science I" addresses key contributions of computer science to general education. The course deals with the thoughtful choice of educational contents for computer science - course 272-0201-00L - is compulsory. The general objective of the course consists in highlighting the tight connection between the mathematical and algorithmic way of thinking and the approaches adopted by engineering disciplines, and in reflecting on teaching approaches for sustainable computer science teaching activities.

Objective

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science.

The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.
The course "Subject Didactics of Computer Science I" addresses key contributions of computer science to general education. The chosen topics support the young learners in developing a unique and indispensable way of thinking, in enhancing their understanding of our world as well as in achieving university education entrance qualifications.

The main topics of the course unit "Subject Didactics of Computer Science I" are the didactics of finite state automata, of formal languages and of the introduction to programming. The unit focuses on contents of computer science that contribute to general education. This involves the understanding of fundamental scientific concepts such as algorithm, complexity, determinism, computation, automata, verification, testing and programming language as well as the way to embed them into a scientifically sound and didactically sustainable computer science course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes
Unterlagen und Folien werden zur Verfügung gestellt.

Literature
J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen"
Lehrwerksreihe "Einfach Informatik"

https://einfachinformatik.inf.ethz.ch/


Prerequisites / notice
Lehrdiplom-Studierende müssen diese Lerneinheit zusammen mit dem Einführungspraktikum Informatik - 272-0201-00L - belegen.

271-0102-00L Teaching Internship Including Examination Lessons in Computer Science
Teaching Internship Computer Science for TC.

Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.

Abstract
Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.
Content

Abstract
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

Objective
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content
Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Literature
Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>272-0103-00L</td>
<td>Mentored Work Subject Didactics Computer Science</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
<tr>
<td></td>
<td>Mentored Work Subject Didactics in Computer Science for TC and Teaching Diploma.</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Abstract
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

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The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content
Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Literature
Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Specialized Courses in Respective Subject with Educational Focus

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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>272-0400-00L</td>
<td>Mentored Work Specialised Courses in the Respective Subject with Educational Focus Computer Science</td>
<td>W+</td>
<td>2</td>
<td>4A</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
</tbody>
</table>

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content
Thematic Schwerpunkte
Die mentorierte Arbeit in FV besteht in der Regel in einer Literaturarbeit über ein Thema, das einen Bezug zum gymnasialem Unterricht oder seiner Weiterentwicklung in FV praktisch um.

Lernformen:

Literature
Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt. Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Prerequisites / notice
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
</tbody>
</table>

Abstract
Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection

Objective
After this course, students will:
Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
Be able to learn new languages more rapidly.
Be aware of many subtle problems of object-oriented programming and know how to avoid them.
Content

The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

Literature

Will be announced in the lecture.

Prerequisites / notice

Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

252-0417-00L Randomized Algorithms and Probabilistic Methods W 10 credits 3V+2U+4A A. Steger

Abstract

Las Vegas & Monte Carlo algorithms: inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, SAT, card shuffling, random walks

Objective

After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content

Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes

Yes.

Literature


252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solving modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous learning algorithms on real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

PhD students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

263-2800-00L Design of Parallel and High-Performance Computing W 9 credits 3V+2U+3A T. Hoefler, M. Püschel

Number of participants limited to 25.

Abstract

Advanced topics in parallel and high-performance computing.

Objective

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

Computer Science TC - Key for Type

| O   | Compulsory          | E-  | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended | Z   | Courses outside the curriculum       |
| W   | Eligible for credits | Dr  | Suitable for doctorate               |

Key for Hours

| V   | lecture             | P   | practical/laboratory course         |
| G   | lecture with exercise | A   | independent project                 |
| U   | exercise            | D   | diploma thesis                      |
| S   | seminar             | R   | revision course / private study     |
| K   | colloquium          |     |                                     |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
# Educational Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
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<td>Cognitive Activating Instructions in MINT Subjects</td>
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<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
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<td>the MINT Learning Center of the ETH Zurich. In the</td>
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<td>- Get information about recent literature on learning</td>
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<td>Unterschiede und ihre Folgen&quot; by Stern and Neubauer.</td>
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<td>book. Furthermore, in two meetings of 90 minutes,</td>
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<td>concept papers developed in small groups (5 - 10</td>
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<td>- Understand research methods used in the empirical</td>
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<td>- Getting to know intelligence tests</td>
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<td>- Understanding findings relevant for education</td>
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<td>Research Methods in Educational Science</td>
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<td>C. M. Thurn, T. Braas, P.</td>
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<td>Literature from the learning sciences is critically</td>
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<td>discussed with a focus on research methods. At the</td>
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<td>first meeting, working groups will be assembled and</td>
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<td>meetings with those will be set up.</td>
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<td>In the small groups students will write critical essays</td>
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<td>about the read literature. At the third meeting, we</td>
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<td>will discuss the essays and develop research questions</td>
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<td>in group work.</td>
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<td>educational sciences</td>
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<td>- Understand and critically examine information from</td>
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<td>- Understand pedagogically relevant findings from the</td>
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<td>851-0242-11L</td>
<td>Gender Issues In Education and STEM</td>
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<td>M. Berkowitz Biran, T. Braas,</td>
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<td>notice</td>
<td>Human Learning (EW1) in parallel, or to have</td>
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<td>successfully completed it.</td>
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<td>Abstract</td>
<td>In this seminar, we introduce some of the major</td>
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<td>gender-related issues in the context of education</td>
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<td>and science learning, such as the under-</td>
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<td>representation of girls and women in science,</td>
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<td>Common perspectives, controversies and empirical</td>
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<td>evidence will be discussed.</td>
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<td>- To develop a critical view on existing research and</td>
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<td>- To integrate this knowledge with teacher's work.</td>
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<td>Content</td>
<td>Why do fewer women than men specialize in STEM (</td>
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<td>science, technology, engineering and mathematics)? Are</td>
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<td>girls better in language and boys better in</td>
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<td>math? These and other questions about gender</td>
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<td>differences relevant to education and STEM learning</td>
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<td>have been occupying researchers for decades. In this</td>
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<td>seminar, students learn about major gender issues in</td>
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<td>the educational context and the different perspectives</td>
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<td>Human Learning (EW1).</td>
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see Educational Science Teaching Diploma

| Number          | Support and Diagnosis of Knowledge Acquisition       | W    | 3    | 3S    | C. M. Thurn, S. Daguati, P.     |
|-----------------|-----------------------------------------------------|------|------|-------| Edelsbrunner                    |
|                 | Processes (EW3). Enrolment only possible with        |      |      |       |                                |
|                 | matriculation in Teaching Diploma (except for the    |      |      |       |                                |
|                 | students of Sport Teaching Diploma, who complete the |      |      |       |                                |
|                 | sport-specific course unit EW3) and for students     |      |      |       |                                |
|                 | who intend to enrol in the "Teaching Diploma".       |      |      |       |                                |

More informations at: https://www.ethz.ch/de/studium/didaktische-ausbildung/studienangebot-zulassung/lehrdiplom-fuer-maturitaetsschulen.html
Prerequisites: successful participation in 851-0240-00L
"Human Learning (EW1)".

Abstract
In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

Objective
The main goals are:
1. You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
2. You have a basic understanding about psychological test theory and can appropriately administer tests.
3. You know various techniques of formative assessment and can apply these to uncover students’ misconceptions.

Subject Didactics in Computer Science

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

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<td>4 credits</td>
<td>3G</td>
<td>G. Serafini, J. Hromkovic</td>
</tr>
</tbody>
</table>

Simultaneous enrolment in Introductory Practical in Computer Science - course 272-0201-00L - is compulsory.

Abstract
The unit “Subject Didactics of Computer Science I” addresses key contributions of computer science to general education. The course deals with the thoughtful choice of educational contents for computer science classes, which takes into account its comprehensibility for different age groups as well as didactic approaches suitable for a successful knowledge transfer.

Objective
The general objective of the course consists in highlighting the tight connection between the mathematical and algorithmic way of thinking and the approaches adopted by engineering disciplines, and in reflecting on teaching approaches for sustainable computer science teaching activities.

The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students know various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

Content
The course “Subject Didactics of Computer Science I” addresses key contributions of computer science to general education. The chosen topics support the young learners in developing a unique and indispensable way of thinking, in enhancing their understanding of our world as well as in achieving university education entrance qualifications.

The main topics of the course unit “Subject Didactics of Computer Science I” are the didactics of finite state automata, of formal languages and of the introduction to programming. The unit focuses on contents of computer science that contribute to general education. This involves the understanding of fundamental scientific concepts such as algorithm, complexity, determinism, computation, automata, verification, testing and programming language as well as the way to embed them into a scientifically sound and didactically sustainable computer science course.

In a semester exercise, the students develop and document an adaptive teaching unit for computer science. They learn to employ the didactics methods and techniques that are introduced at the beginning of the semester.

Lecture notes
Unterlagen und Folien werden zur Verfügung gestellt.

Literature
J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen"
Lehrwerksreihe "Einfach Informatik"
https://einfachinformatik.inf.ethz.ch/


Prerequisites / notice
Lehrdiplom-Studierende müssen diese Lerneinheit zusammen mit dem Einführungspraktikum Informatik - 272-0201-00L - belegen.
The objective is for the students:

**Concepts and Theories**
- assessed

**Analytical Competencies**
- assessed

**Decision-making**
- assessed

**Media and Digital Technologies**
- assessed

**Problem-solving**
- assessed

**Project Management**
- not assessed

**Communication**
- assessed

**Cooperation and Teamwork**
- assessed

**Customer Orientation**
- assessed

**Leadership and Responsibility**
- assessed

**Self-presentation and Social Influence**
- assessed

**Sensitivity to Diversity**
- assessed

**Negotiation**
- assessed

**Adaptability and Flexibility**
- assessed

**Creative Thinking**
- assessed

**Critical Thinking**
- assessed

**Integrity and Work Ethics**
- assessed

**Self-awareness and Self-reflection**
- assessed

**Self-direction and Self-management**
- assessed

---

**Mentored Work Subject Didactics**

**Computer Science**

**ECTS:** 4A

**Number:** 272-0103-00L

**Title:** Mentored Work Subject Didactics Computer Science

**Type:** A

**Credits:** 2

**Hours:** 4A

**Lecturers:** J. Hromkovic, G. Serafini

**Abstract:**
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

**Objective:**
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

**Content:**
Thematic Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


**Literature:**
Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

**Prerequisites / notice:**
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

---

**Mentored Work Subject Didactics**

**Computer Science**

**ECTS:** 4A

**Number:** 272-0104-00L

**Title:** Mentored Work Subject Didactics Computer Science

**Type:** B

**Credits:** 2

**Hours:** 4A

**Lecturers:** J. Hromkovic, G. Serafini

**Abstract:**
In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

**Objective:**
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

**Content:**
Thematic Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


**Literature:**
Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

**Prerequisites / notice:**
Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

---

**Professional Training**

**Important:** You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
272-0201-00L | Introductory Practical in Computer Science | O | 3 | 6P | J. Hromkovic, G. Serafini

**Abstract:**
During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.
Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training.

The students carry out individually specified, practice related projects, in which they support, document or reflect on learning processes.

**Abstract**

*In the course Professional Exercises the students achieve additional school-relevant experiences. The students carry out individually specified, practice related projects, in which they support, document or reflect on learning processes.*

**Objective**

Achievement of additional school-relevant experiences. The students carry out individually specified, practice related projects, in which they support, document or reflect on learning processes.

**Content**

The course Professional Exercises offers the opportunity for additional school-relevant activities.

**Literature**

Wird von der Praktikumslehrperson bestimmt.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>ECTS</th>
<th>Type</th>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>272-0202-00L</td>
<td>Professional Exercises</td>
<td>2</td>
<td>O</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
<tr>
<td>272-0203-00L</td>
<td>Teaching Internship in Computer Science</td>
<td>8</td>
<td>O</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
<tr>
<td>272-0204-00L</td>
<td>Teaching Internship for students upgrading TC to Teaching Diploma</td>
<td>4</td>
<td>W</td>
<td>J. Hromkovic, G. Serafini</td>
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<tr>
<td>272-0205-01L</td>
<td>Examination Lesson I in Computer Science</td>
<td>1</td>
<td>O</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
<tr>
<td>272-0205-02L</td>
<td>Examination Lesson II in Computer Science</td>
<td>1</td>
<td>O</td>
<td>J. Hromkovic, G. Serafini</td>
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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>272-0400-00L</td>
<td>Mentored Work Specialised Courses in the Respective O</td>
<td>2</td>
<td>credits</td>
<td>4A</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
<tr>
<td></td>
<td>Subject with Educational Focus Computer Sc A</td>
<td></td>
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<tr>
<td>Abstract</td>
<td>In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.</td>
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<tr>
<td>Objective</td>
<td>The aim is for the students to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way. - to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership. - To try out different options for specialist further training in their profession.</td>
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<tr>
<td>Literature</td>
<td>Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.</td>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>272-0401-00L</td>
<td>Mentored Work Specialised Courses in the Respective O</td>
<td>2</td>
<td>credits</td>
<td>4A</td>
<td>J. Hromkovic, G. Serafini</td>
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<td></td>
<td>Subject with Educational Focus Computer Sc B</td>
<td></td>
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<tr>
<td>Abstract</td>
<td>In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.</td>
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<td>Objective</td>
<td>The aim is for the students to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way. - to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership. - To try out different options for specialist further training in their profession.</td>
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<td>Literature</td>
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<td>Prerequisites / notice</td>
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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8</td>
<td>credits</td>
<td>p. Müller</td>
</tr>
<tr>
<td></td>
<td>Course focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection</td>
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<tr>
<td>Abstract</td>
<td>After this course, students will: Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features. Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs. Be able to learn new languages more rapidly. Be aware of many subtle problems of object-oriented programming and know how to avoid them.</td>
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<tr>
<td>Objective</td>
<td>The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages. The topics discussed in the course include among others:</td>
<td></td>
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<tr>
<td>Content</td>
<td>The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing) The key problems of single and multiple inheritance and how different languages address them. Generic type systems, in particular, Java generics, C# generics, and C++ templates. The situations in which object-oriented programming does not provide encapsulation, and how to avoid them. The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing How to maintain the consistency of data structures</td>
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</tbody>
</table>
Randomized Algorithms and Probabilistic Methods

Abstract
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

Objective
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes
Yes.

Literature

Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

Design of Parallel and High-Performance Computing

Number of participants limited to 125.

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallel Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

see Compulsory Elective Courses Teaching Diploma
## Computer Science Teaching Diploma - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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## Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Computer Science Master

Majors

Major in Data Management Systems

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>263-3010-00L</td>
<td>Big Data</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>G. Fourny</td>
</tr>
</tbody>
</table>

Abstract

The key challenge of the information society is to turn data into information, information into knowledge, knowledge into value. This has become increasingly complex. Data comes in larger volumes, diverse shapes, from different sources. Data is more heterogeneous and less structured than forty years ago. Nevertheless, it still needs to be processed fast, with support for complex operations.

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes referred to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters; starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage(S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (? , *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Literature

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases): this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists): Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the analysis and model building in order to solve real-world problems, whereas the goal is to come up with the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data. Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.
The first part of the course covers general security concepts and hardware-based support for security. The second part focuses on system design and methodologies for building secure systems.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug- detection, writing secure software (design, architecture, QA, testing), compiler- supported security (e.g., control- flow integrity), and language- supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug- detection, writing secure software (design, architecture, QA, testing), compiler- supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

The participation in the course is subject to the following condition: Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

### Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

### Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CLL/

### Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

### Statistical Learning Theory
http://mi2.inf.ethz.ch/courses/mlt/

### Computational Statistics
https://stat.ethz.ch/lectures/as19/comp-stats.php

### Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

The goal is not to provide a comprehensive introduction to formal methods - this is well covered by other courses in the department. Instead, it is intended to provide students in computer systems (who may or may not have existing background knowledge of formal methods) with a basis for applying formal methods in their work.

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

The course is about how to apply concepts, techniques, and principles from formal methods to such practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallelle Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security, and language-supported security (e.g., memory safety).

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### Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

### Computational Intelligence Lab
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### Introduction to Machine Learning
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### Probabilistic Artificial Intelligence
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The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
## Core Courses

### 252-0535-00L Advanced Machine Learning

**Number:** 252-0535-00L  
**Title:** Advanced Machine Learning  
**Type:** W  
**ECTS:** 10 credits  
**Hours:** 3V+2U+4A  
**Lecturers:** J. M. Buhmann, C. Cotrini Jimenez

**Abstract**  
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**  
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

**Content**  
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:  
  - What is data?  
  - Bayesian Learning  
  - Computational learning theory

- Supervised learning:  
  - Ensembles: Bagging and Boosting  
  - Max Margin methods  
  - Neural networks

- Unsupervised learning:  
  - Dimensionality reduction techniques  
  - Clustering  
  - Mixture Models  
  - Non-parametric density estimation  
  - Learning Dynamical Systems

**Lecture notes**  
No lecture notes, but slides will be made available on the course webpage.

**Literature**  


**Prerequisites / notice**  
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

### 263-3210-00L Deep Learning

**Number of participants limited to 320.**  
**W**  
**ECTS:** 8 credits  
**Hours:** 3V+2U+2A  
**Lecturers:** T. Hofmann, F. Perez Cruz, N. Perraudin

**Abstract**  
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**  
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

**Prerequisites / notice**  
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00L) or have acquired equivalent knowledge, see exhaustive list below:
  
  Advanced Machine Learning  
  [https://ml2.inf.ethz.ch/courses/aml/](https://ml2.inf.ethz.ch/courses/aml/)
  
  Computational Intelligence Lab  
  
  Introduction to Machine Learning  
  [https://las.inf.ethz.ch/teaching/introml-S19](https://las.inf.ethz.ch/teaching/introml-S19)
  
  Statistical Learning Theory  
  [http://ml2.inf.ethz.ch/courses/slt/](http://ml2.inf.ethz.ch/courses/slt/)
  
  Computational Statistics  
  
  Probabilistic Artificial Intelligence  
  [https://las.inf.ethz.ch/teaching/pai-f18](https://las.inf.ethz.ch/teaching/pai-f18)
The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and assessed.

Creative Thinking

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit “intelligent” behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

Content

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

Prerequisites / notice

Solid basic knowledge in statistics, algorithms and programming. The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>263-3005-00L</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
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<tr>
<td></td>
<td>Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.</td>
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<td>The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.</td>
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<td>Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.</td>
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<td>This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<td>The course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.</td>
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<td>While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in &quot;Intro to ML&quot; classes at most institutions (e.g., &quot;Introduction to Machine Learning&quot; at ETH).</td>
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<td>For solving assignments, some programming experience in Python is expected.</td>
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<tr>
<td>263-2400-00L</td>
<td>Reliable and Trustworthy Artificial Intelligence</td>
<td>W</td>
<td>6</td>
<td>2V+2U+1A</td>
<td>M. Vechev</td>
</tr>
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<td></td>
<td>Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.</td>
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<td>Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.</td>
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<td>The course is split into 3 parts:</td>
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<td>Robustness in Deep Learning</td>
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<td></td>
<td>- Adversarial attacks and defenses on deep learning models.</td>
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<td>- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomization smoothing).</td>
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<td>- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).</td>
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<td>Privacy of Machine Learning</td>
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<td>- Threat models (e.g., stealing data, poisoning, membership inference, etc.).</td>
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<td>- Attacking federated machine learning (across modalities such as vision, natural language and tabular).</td>
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<td>- Differential privacy for defending machine learning.</td>
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<td>- Enforcing regulations with guarantees (e.g., via provable data minimization).</td>
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<td>Fairness of Machine Learning</td>
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<td>- Introduction to fairness (motivation, definitions).</td>
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<td>- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).</td>
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<td>- Enforcing group fairness with guarantees.</td>
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<td>For solving assignments, some programming experience in Python is expected.</td>
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<td>Subject-specific Competencies</td>
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<td></td>
<td>Concepts and Theories assessed</td>
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<td></td>
<td>Techniques and Technologies assessed</td>
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<td></td>
<td>Analytical Competencies assessed</td>
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<td>Problem-solving assessed</td>
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<td>Creative Thinking assessed</td>
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<td>Critical Thinking assessed</td>
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<tr>
<td>263-5005-00L</td>
<td>Artificial Intelligence in Education</td>
<td>W</td>
<td>3</td>
<td>1V+0.5U</td>
<td>M. Sachan, T. Sinha</td>
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<td>Artificial Intelligence (AI) methods have shown to have a profound impact in educational technologies, where the great variety of tasks and data types enable us to get benefit of AI techniques in many different ways. We will review relevant methods and applications of AI in various educational technologies, and work on problem sets and projects to solve problems in education with the help of AI.</td>
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<td>The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussion, and b) work on problem-sets exemplifying the use of educational data mining techniques.</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1287 of 2416
The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content curation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

Lecture slides will be made available at the course Web site.

No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

By the end of the semester students should be able to
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover "new" applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes will be posted on Moodle.

Dynamic Programming and Optional Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepevszki

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in individual exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)
Major in Secure and Reliable Systems

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7 credits</td>
<td>2V+2U+2A</td>
<td>D. Basin, M. Ochoa Ronderos</td>
</tr>
</tbody>
</table>

Abstract

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Literature

The literature will be provided by the instructors on the class website.

Prerequisites / notice

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.
Objective

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

- security requirements & risk analysis,
- system modeling and model-based development methods,
- implementation-level security, and
- evaluation criteria for the development of secure systems
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Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class
2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security
3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts
4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience
5. Model-driven security (Part II)
   - Continuation of above topics
6. Security patterns (design and implementation)
7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks
8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis
9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties
10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment
11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience
12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection
13. Guest lecture
    - TBA

Literature

More relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice
Prerequisite: Class on Information Security
Content

The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-2800-00L Design of Parallel and High-Performance Computing

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing W</td>
<td>9</td>
<td>3V+2U+3A</td>
<td></td>
<td>T. Hoefler, M. Püschel</td>
</tr>
</tbody>
</table>

Abstract

Advanced topics in parallel and high-performance computing.

Objective

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-4640-00L Network Security

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>263-4640-00L</td>
<td>Network Security W</td>
<td>8</td>
<td>2V+2U+3A</td>
<td></td>
<td>A. Perrig, S. Frei, M. Legner, K. Paterson</td>
</tr>
</tbody>
</table>

Abstract

Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

Objective

- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

Content

The course will cover topics spanning four broad themes with a focus on the first two themes:

1. Network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. Network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. Analysis and inference topics such as traffic monitoring and network forensics; and

Prerequisites / notice

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview is assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L.

Fostered competencies

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management.
- Social Competencies: Adaptability and Flexibility, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management.

Autumn Semester 2022
### Abstract
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

### Objective
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

### Content
The course is split into 3 parts:

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

### Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

### For solving assignments, some programming experience in Python is expected.

### 263-4657-00L Advanced Encryption Schemes

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Public-Key Encryption has had a significant impact by enabling remote parties to communicate securely via an insecure channel. Latest schemes go further by providing a fine-grained access to the encrypted data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.</td>
</tr>
<tr>
<td>Content</td>
<td>We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.</td>
</tr>
<tr>
<td>Literature</td>
<td>Links to relevant research papers will be given in the course materials.</td>
</tr>
</tbody>
</table>

### Prerequisites / notice
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

### 263-4665-00L Zero-Knowledge Proofs

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Zero-knowledge proofs are protocols which allow a prover to convince a verifier that a statement is true without leaking any information beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.</th>
</tr>
</thead>
</table>
| Objective | - To understand what it means for a zero-knowledge proof to be secure  
- To understand what it means for a zero-knowledge proof to be secure  
- To construct and analyse various types of zero-knowledge proofs  
- To understand some applications of zero-knowledge proofs |
| Content | The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in cryptography and the real world. The course may also describe some more advanced constructions of non-interactive proofs. |
| Lecture notes | The course notes will be written in English. |

### Prerequisites / notice
Students should have taken a first course in Cryptography (as taught in the Information Security course at Bachelor's level). Experience with algebra and probability is desirable.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Personal Competencies</th>
<th>Creative Thinking</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

### 227-0579-00L Hardware Security

<table>
<thead>
<tr>
<th>Abstract</th>
<th>This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks.</th>
</tr>
</thead>
</table>
| Objective | By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about:  
- security problems of commodity hardware that we use everyday and how you can defend against them.  
- relevant computer architecture and operating system aspects of these issues.  
- hands-on techniques for performing hardware attacks.  
- writing critical reviews and constructive discussions with peers on this topic. |
| Literature | This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course. |

### Prerequisites / notice
Experience with Linux, systems programming and computer architecture.
## Major in Theoretical Computer Science

### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>A. Steger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Las Vegas &amp; Monte Carlo algorithms; inequalities of Markov, Chebyshev, Cernhoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks</td>
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<tr>
<td>Objective</td>
<td>After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Randomized Algorithms are algorithms that &quot;flip coins&quot; to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.</td>
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</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
<tr>
<td>Abstract</td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solving modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.</td>
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</tr>
<tr>
<td>Content</td>
<td>The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
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</tbody>
</table>

**Prerequisites / notice**
- The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.
- Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.
- PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-1425-00L</td>
<td>Geometry: Combinatorics and Algorithms</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>B. Gärtner, E. Welzl, M. Hoffmann</td>
</tr>
<tr>
<td>Abstract</td>
<td>Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.</td>
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</tr>
<tr>
<td>Content</td>
<td>Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in R^d, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.</td>
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<tr>
<td>Lecture notes</td>
<td>Yes.</td>
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</tbody>
</table>
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

### Elective Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>A. Lapidoth</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The fundamentals of Information Theory including Shannon's source coding and channel coding theorems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>T.M. Cover and J. Thomas, Elements of Information Theory (second edition)</td>
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</tr>
</tbody>
</table>

| 263-5300-00L| Guarantees for Machine Learning            | W    | 7    | 3V+1U+2A | F. Yang, A. Sanyal |
| Title       | Number of participants limited to 30.     |
| Abstract    | This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results. |
| Objective   | By the end of the semester students should be able to |
| Content     | - understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work |
|             | - critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions |
|             | - outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project |
|             | - effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks. |
| Prerequisites / notice | Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs. |
| Fostered competencies | Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH) |
| Subject-specific Competencies | Concepts and Theories assessed |
| Method-specific Competencies | Analytical Competencies assessed |
| Social Competencies | Communication assessed |
| Personal Competencies | Creative Thinking assessed |

| 401-3054-14L| Probabilistic Methods in Combinatorics     | W    | 6    | 2V+1U | B. Sudakov         |
| Title       | Does not take place this semester.        |
| Abstract    | This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems. |
| Content     | The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness. |
|             | - Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002. |

| 401-3055-64L| Algebraic Methods in Combinatorics        | W    | 6    | 2V+1U | B. Sudakov         |
| Title       | Does not take place this semester.        |
| Abstract    | Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. |
| Objective   | The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems. |

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1295 of 2416
This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the methods for rendering these objects to create photorealistic images. The course will cover topics such as geometry, shading, light transport, and image synthesis. Students will be expected to build a rendering system and apply these concepts in practical projects.

- Students are expected to have a mathematical background and should be able to write rigorous proofs.
- Solid background in linear algebra.
- Experience with computer science fundamentals, especially programming.

### Literature

### Prerequisites / notice
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely. Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Content
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

### Methods and Technologies
- Equivalence between optimization and separation.
- Combinatorial optimization problems and polyhedral techniques;
- Linear programming and polyhedra;
- Flows and cuts;

### Fostered competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Not assessed
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Notice
The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

### Major in Visual and Interactive Computing

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0543-01L</td>
<td>Computer Graphics</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>M. Gross, M. Papas</td>
</tr>
</tbody>
</table>

#### Abstract
This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

#### Objective
At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

#### Content
This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

### Contents
- Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

### Prerequisites
- Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.

The programming assignments will be in C++. This will not be taught in the class.

### Elective Courses

#### Physically-Based Simulation in Computer Graphics
- **Number**: 252-0546-00L
- **Title**: Physically-Based Simulation in Computer Graphics
- **Type**: W
- **ECTS**: 5 credits
- **Hours**: 2V+1U+3A
- **Lecturers**: S. Coros, B. Thomaszewski, V. da Costa de Azevedo

#### Mixed Reality
- **Number**: 263-5905-00L
- **Title**: Mixed Reality
- **Type**: W
- **ECTS**: 5 credits
- **Hours**: 3G+1A
- **Lecturers**: I. Armeni, M. Pollefeys

### Seminar
- **Number**: 252-3811-00L
- **Title**: Case Studies from Practice Seminar
- **Type**: W
- **ECTS**: 4 credits
- **Hours**: 2S
- **Lecturers**: M. Brandis

The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

### Prerequisites / notice
- Prerequisites include:
  - Good programming skills (C# / C++ / Java etc.)
  - Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.
The seminar covers various topics in information security: security protocols (models, specification & verification), trust management, access control, non-interference, side-channel attacks, identity-based cryptography, host-based attack detection, anomaly detection in backbone networks, key-management for sensor networks.

**Objective**
The main goals of the seminar are the independent study of scientific literature and assessment of its contributions as well as learning and practicing presentation techniques.

**Content**
The seminar covers various topics in information security, including network security, cryptography and security protocols. The participants are expected to read a scientific paper and present it in a 35-40 min talk. At the beginning of the semester a short introduction to presentation techniques will be given.

**Selected Topics**
- security protocols: models, specification & verification
- trust management, access control and non-interference
- side-channel attacks
- identity-based cryptography
- host-based attack detection
- anomaly detection in backbone networks
- key-management for sensor networks

**Literature**
The reading list will be published on the course web site.
This seminar aims to familiarize students with current research topics in fast graph algorithms and optimization. The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Objective**

Preparation and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize a presentation and lead the subsequent discussion.

**Abstract**

Students taking this seminar should have the necessary background in systems and low level programming.

**Prerequisites / notice**

- Participation will be limited subject to available topics. Furthermore, students will have to submit a motivation paragraph. Participants will be selected based on this paragraph.
- All other students: read the paper and submit questions they have about the paper before the presentation.
- The deadline for deregistering expires at the end of the second week of the semester. Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

**Prerequisites / notice**

- Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

**Objectives**

- The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.
- Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

**Number of participants limited to 24.**

**Number of participants limited to 18.**

**Number of participants limited to 6.**

**Methods**

- Reading papers on cutting edge research topics; learn how to give a scientific talk.
- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.
- The general application areas are big data and machine learning. The systems covered will include systems from computer architecture, high performance computing, data appliances, and data centers.

**Number of participants limited to 20.**

**Prerequisites / notice**

- As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Prerequisites / notice**

- passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Objective**

- Preparing and holding a scientific presentation in front of peers is a central part of working in the scientific domain. In this seminar, the participants will learn how to efficiently summarize the relevant parts of a scientific publication, critically reflect its contents, and summarize it for presentation to an audience. The necessary skills to successfully present the key points of existing research work are the same as those needed to communicate own research ideas. In addition to holding a presentation, each student will both contribute to as well as lead a discussion section on the topics presented in the class.

**Abstract**

- The seminar will cover topics related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

**Number of participants limited to 24.**

**Number of participants limited to 18.**

**Number of participants limited to 6.**

**Methods**

- The topics covered in the seminar are related to recent computational challenges that arise in the medical field, including but not limited to clinical data analysis, interpretable machine learning, privacy considerations, statistical frameworks, etc. Both recently published works contributing novel ideas to the areas mentioned above as well as seminal contributions from the past are on the list of selected papers.

**Number of participants limited to 20.**

**Prerequisites / notice**

- Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

**Prerequisites / notice**

- Students who are still registered after that date, but do not attend the seminar, will officially fail the seminar.

**Objectives**

- As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Abstract**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 6.**

**Methods**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 24.**

**Number of participants limited to 20.**

**Prerequisites / notice**

- Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

**Objectives**

- As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Abstract**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 6.**

**Methods**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 24.**

**Number of participants limited to 20.**

**Prerequisites / notice**

- Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

**Objectives**

- As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Abstract**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 6.**

**Methods**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 24.**

**Number of participants limited to 20.**

**Prerequisites / notice**

- Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.

**Objectives**

- As prerequisite we require that you passed the course "Advanced Graph Algorithms and Optimization". In exceptional cases, students who passed one of the courses "Randomized Algorithms and Probabilistic Methods", "Optimization for Data Science", or "Advanced Algorithms" may also participate, at the discretion of the lecturer.

**Abstract**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 6.**

**Methods**

- The seminar will cover topics related to data processing using new hardware in general and hardware accelerators (GPU, FPGA, specialized processors) in particular.

**Number of participants limited to 24.**

**Number of participants limited to 20.**

**Prerequisites / notice**

- Knowledge of machine learning and interest in applications in medicine. ML4H is beneficial as a prior course.
The Applied Security Laboratory addresses four major topics: operating system security (hardening, vulnerability scanning, access control, and configuration of security mechanisms, risk analysis, system review), information security, operating system security, QoS, hardening, computer forensics, web application security, project work, design, implementation, and configuration of security mechanisms, risk analysis, system review.

Objective
The goal is to get an overview of actual research topics in the field of digital humans and to improve presentation and critical analysis skills. The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.

Content
This course emphasizes applied aspects of Information Security. The students will study a number of topics in a hands-on fashion and carry out experiments in order to better understand the need for secure implementation and configuration of IT systems and to assess the effectiveness and impact of security measures. This part is based on a book and virtual machines that include example applications, questions, and answers.

The students will also complete an independent project: based on a set of functional requirements, they will design and implement a prototypical IT system. In addition, they will conduct a thorough security analysis and devise appropriate security measures for their systems. Finally, they will carry out a technical and conceptual review of another system. All project work will be performed in teams and must be properly documented.

Literature
Recommended reading includes:
* Various: OWASP Guide to Building Secure Web Applications, available online
* O'Reilly, Loukides: Unix Power Tools, O'Reilly & Associates.
* Frisch: Essential System Administration, O'Reilly & Associates.
* NIST: Risk Management Guide for Information Technology Systems, available online as PDF
* BSI: IT-Grunschutzhandbuch, available online
This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the

Objective
Gain hands-on-experience with real products and the latest technology in distributed systems.

Content
This course involves the participation in a substantial development and/or evaluation project involving distributed systems technology. There are projects available in a wide range of areas: from web services to ubiquitous computing including wireless networks, ad-hoc networks, and distributed applications on smartphones. The goal of the project is for the students to gain hands-on-experience with real products and the latest technology in distributed systems. There is no lecture associated to the course.

252-0546-00L

Physically-Based Simulation in Computer Graphics

Objective
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Content
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Prerequisites / notice
Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

Practical work refers either to a semester project or a lab course, which is conducted under the supervision of a professor of the department of computer science.

Prerequisites / notice
* The lab allows flexible working since there are only few mandatory deadlines during the semester.
* The lab covers a variety of different techniques. Thus, participating students should have a solid foundation in the following areas: information security, operating system administration (especially Unix/Linux), and networking. Students are also expected to have a basic understanding of HTML, PHP, JavaScript, and MySQL because several examples are implemented in these languages.
* Students must be prepared to spend more than three hours per week to complete the lab assignments and the project. This applies particularly to students who do not meet the recommended requirements given above. Successful participants of the course receive 8 credits as compensation for their effort.
* All participants must sign the lab's charter and usage policy during the introduction lecture.

263-0590-00L

Mixed Reality

Objective
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Content
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to Distributed Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course is student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.
Minor in Computer Vision

263-3210-00L Deep Learning
- W 8 credits 3V+2U+2A C. Cotrini Jimenez, T. Hofmann, F. Perez Cruz.
- Hours Type ECTS Lecturers

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is to understand why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following conditions:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

263-3202-00L Computer Vision
- W 8 credits 3V+1U+3A M. Pollefeys, S. Tang, F. Yu

Abstract
The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

Objective
The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content
Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice
It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

263-5902-00L Mixed Reality
- W 5 credits 3G+1A I. Armeni, M. Pollefeys

Abstract
The goal of this course is an introduction and hands-on experience on latest mixed reality technology at the cross-section of 3D computer graphics and vision, human machine interaction, as well as gaming technology.

Objective
After attending this course, students will:
1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

Content
The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including: Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics-HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites / notice
Prerequisites include:
- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

Minor in Data Management

252-0535-00L Advanced Machine Learning
- W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Topics covered in the lecture include:

- **Fundamentals:**
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- **Supervised learning:**
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- **Unsupervised learning:**
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

No lecture notes, but slides will be made available on the course webpage.

### Literature


PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Semester</th>
<th>Credits</th>
<th>Type</th>
<th>Prerequisites / Notice</th>
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<tbody>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>W</td>
<td>9 credits</td>
<td>3V+2U+3A</td>
<td>T. Hoefler, M. Püschel</td>
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<tr>
<td>263-3010-00L</td>
<td>Big Data</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>G. Fourny</td>
</tr>
</tbody>
</table>

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**263-2800-00L - Design of Parallel and High-Performance Computing**  
**Number of participants limited to 125.**

**Objective**

Advanced topics in parallel and high-performance computing.

**Content**

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice**

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

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**263-3010-00L - Big Data**

**Objective**

Do you want to be able to query your own data productively and efficiently in your future semester projects, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

"Big Data" refers to the case when the amount of data is very large (100 GB and more), or when the data is not completely structured (or messy). The Big Data revolution has led to a completely new way to do business, e.g., develop new products and business models, but also to do science -- which is sometimes related to as data-driven science or the "fourth paradigm".

Unfortunately, the quantity of data produced and available -- now in the Zettabyte range (that's 21 zeros) per year -- keeps growing faster than our ability to process it. Hence, new architectures and approaches for processing it are needed. Harnessing them must involve a deep understanding of data not only in the large, but also in the small.

The field of databases evolves at a fast pace. In order to be prepared, to the extent possible, to the (r)evolutions that will take place in the next few decades, the emphasis of the lecture will be on the paradigms and core design ideas, while today's technologies will serve as supporting illustrations thereof.

After visiting this lecture, you should have gained an overview and understanding of the Big Data landscape, which is the basis on which one can make informed decisions, i.e., pick and orchestrate the relevant technologies together for addressing each one of your projects efficiently and consistently.
Content

This course gives an overview of database technologies and of the most important database design principles that lay the foundations of the Big Data universe. We take the monolithic, one-machine relational stack from the 1970s, smash it down and rebuild it on top of large clusters: starting with distributed storage, and all the way up to syntax, models, validation, processing, indexing, and querying. A broad range of aspects is covered with a focus on how they fit all together in the big picture of the Big Data ecosystem.

No data is harmed during this course, however, please be psychologically prepared that our data may not always be in third normal form.

- physical storage: distributed file systems (HDFS), object storage (S3), key-value stores
- logical storage: document stores (MongoDB), column stores (HBase), graph databases (neo4j), data warehouses (ROLAP)
- data formats and syntaxes (XML, JSON, RDF, Turtle, CSV, XBRL, YAML, protocol buffers, Avro)
- data shapes and models (tables, trees, graphs, cubes)
- type systems and schemas: atomic types, structured types (arrays, maps), set-based type systems (?, *, +)
- an overview of functional, declarative programming languages across data shapes (SQL, XQuery, JSONiq, Cypher, MDX)
- the most important query paradigms (selection, projection, joining, grouping, ordering, windowing)
- paradigms for parallel processing, two-stage (MapReduce) and DAG-based (Spark)
- resource management (YARN)
- what a data center is made of and why it matters (racks, nodes, ...)
- underlying architectures (internal machinery of HDFS, HBase, Spark, neo4j)
- optimization techniques (functional and declarative paradigms, query plans, rewrites, indexing)
- applications.

Large scale analytics and machine learning are outside of the scope of this course.

Literture

Course textbook: https://ghislainfourny.github.io/big-data-textbook/

Papers from scientific conferences and journals. References will be given as part of the course material during the semester.

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

This course, in the autumn semester, is only intended for:
- Computer Science students
- Data Science students
- CBB students with a Computer Science background

Mobility students in CS are also welcome and encouraged to attend. If you experience any issue while registering, please contact the study administration and you will be gladly added.

For students of all other departements interested in this fascinating topic: I would love to have you visit my lectures as well! So there is a series of two courses specially designed for you:
- "Information Systems for Engineers" (SQL, relational databases); this Fall
- "Big Data for Engineers" (similar to Big Data, but adapted for non Computer Scientists); Spring 2023

There is no hard dependency, so you can either them in any order, but it may be more enjoyable to start with Information Systems for Engineers.

Students who successfully completed Big Data for Engineers are not allowed to enrol in the course Big Data.

| Fostered competencies | Subject-specific Competencies | Concepts and Theories | assessed |
| | | Techniques and Technologies | assessed |
| Method-specific Competencies | Analytical Competencies | assessed |
| | Decision-making | assessed |
| | Media and Digital Technologies | not assessed |
| | Problem-solving | not assessed |
| Social Competencies | Communication | not assessed |
| | Sensitivity to Diversity | not assessed |
| | Negotiation | not assessed |
| Personal Competencies | Creative Thinking | not assessed |
| | Critical Thinking | not assessed |
| | Integrity and Work Ethics | not assessed |

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz, N. Perraudin

Number of participants limited to 320.

Abstract

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/

Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/

Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19

Statistical Learning Theory
http://mii.inf.ethz.ch/courses/slt/

Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php

Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-f18

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tr>
<td>252-0463-00L</td>
<td>Security Engineering</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>D. Basin, M. Ochoa Ronderos</td>
</tr>
</tbody>
</table>

Subject of the class are engineering techniques for developing secure systems. We examine concepts, methods and tools, applied within the different activities of the SW development process to improve security of the system. Topics: security requirements & risk analysis, system modeling & model-based development methods, implementation-level security, and evaluation criteria for secure systems.
Objective

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software. Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems
Content

Security engineering is an evolving discipline that unifies two important areas: software engineering and security. Software Engineering addresses the development and application of methods for systematically developing, operating, and maintaining, complex, high-quality software.

Security, on the other hand, is concerned with assuring and verifying properties of a system that relate to confidentiality, integrity, and availability of data.

The goal of this class is to survey engineering techniques for developing secure systems. We will examine concepts, methods, and tools that can be applied within the different activities of the software development process, in order to improve the security of the resulting systems.

Topics covered include

* security requirements & risk analysis,
* system modeling and model-based development methods,
* implementation-level security, and
* evaluation criteria for the development of secure systems

Modules taught:

1. Introduction
   - Introduction of Infsec group and speakers
   - Security meets SW engineering: an introduction
   - The activities of SW engineering, and where security fits in
   - Overview of this class

2. Requirements Engineering: Security Requirements and some Analysis
   - Overview: functional and non-functional requirements
   - Use cases, misuse cases, sequence diagrams
   - Safety and security

3. Modeling in the design activities
   - Structure, behavior, and data flow
   - Class diagrams, statecharts

4. Model-driven security for access control (Part I)
   - SecureUML as a language for access control
   - Combining Design Modeling Languages with SecureUML
   - Semantics, i.e., what does it all mean,
   - Generation
   - Examples and experience

5. Model-driven security (Part II)
   - Continuation of above topics

6. Security patterns (design and implementation)

7. Implementation-level security
   - Buffer overflows
   - Input checking
   - Injection attacks

8. Code scanning
   - Static code analysis basics
   - Theoretical and practical challenges
   - Analysis algorithms
   - Common bug pattern search and specification
   - Dataflow analysis

9. Testing
   - Overview and basics
   - Model-based testing
   - Testing security properties

10. Risk analysis and management
    - "Risk": assets, threats, vulnerabilities, risk
    - Risk assessment: quantitative and qualitative
    - Safeguards
    - Generic risk analysis procedure
    - The OCTAVE approach
    - Example of qualitative risk assessment

11. Threat modeling
    - Overview
    - Safety engineering basics: FMEA and FTA
    - Security impact analysis in the design phase
    - Modeling security threats: attack trees
    - Examples and experience

12. Evaluation criteria
    - NIST special papers
    - ISO/IEC 27000
    - Common criteria
    - BSI baseline protection

13. Guest lecture
    - TBA

Literature

- Further relevant books and journal/conference articles will be announced in the lecture.

Prerequisites / notice

Prerequisite: Class on Information Security

252-1411-00L Security of Wireless Networks  W  6 credits  2V+1U+2A  S. Capkun, K. Kostiainen

Abstract

Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.
After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.


The student is comfortable with formal security definitions and proof techniques used to analyze the security of the latest encryption schemes with advanced features. This prepares the student to start reading research papers on the field.

The course will cover topics spanning four broad themes with a focus on the first two themes:

(1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
(2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
(3) analysis and inference topics such as traffic monitoring and network forensics; and
(4) new technologies related to next-generation networks.

This course provides an in-depth study of network attack techniques and methods to defend against them.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

Some of today’s most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems.

This course is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Links to relevant research papers will be given in the course materials.

It is recommended for students to have prior exposure to cryptography, e.g. the D-INFK course "Digital Signatures" or "Applied Cryptography".

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

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The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

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We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Links to relevant research papers will be given in the course materials.

It is recommended for students to have prior exposure to cryptography, e.g. the D-INFK course "Digital Signatures" or "Applied Cryptography".

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

We will start by presenting the notion of Public-Key Encryption with its various security guarantees and some constructions. Then we will look into encryption schemes with fine-grained access control to the encrypted data, such as identity-based encryption or attribute-based encryption and present different methodology to prove their security.

Links to relevant research papers will be given in the course materials.

It is recommended for students to have prior exposure to cryptography, e.g. the D-INFK course "Digital Signatures" or "Applied Cryptography".
Zero-knowledge proofs are protocols which allow a prover to convince a verifier that a statement is true without leaking any information beyond that fact. This course is a detailed introduction to zero-knowledge proof protocols.

- To understand what it means for a zero-knowledge proof to be secure
- To construct and analyse various types of zero-knowledge proofs
- To understand some applications of zero-knowledge proofs

The course will discuss interactive zero-knowledge proofs based on various cryptographic assumptions, and their applications in cryptography and the real world. The course may also describe some more advanced constructions of non-interactive proofs.

The course notes will be written in English.

Students should have taken a first course in Cryptography (as taught in the Information Security course at Bachelor's level). Experience with algebra and probability is desirable.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0579-00L</td>
<td>Hardware Security</td>
<td>W</td>
<td>7</td>
<td>2V+2U+2A</td>
<td>K. Razavi</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers the security of commodity computer hardware (e.g., CPU, DRAM, etc.) with a special focus on cutting-edge hands-on research. The aim of the course is familiarizing the students with hardware security and more specifically microarchitectural and circuit-level attacks and defenses through lectures, reviewing and discussing papers, and executing some of these advanced attacks. By the end of the course, the students will be familiar with the state of the art in commodity computer hardware attacks and defenses. More specifically, the students will learn about: - security problems of commodity hardware that we use everyday and how you can defend against them. - relevant computer architecture and operating system aspects of these issues. - hands-on techniques for performing hardware attacks. - writing critical reviews and constructive discussions with peers on this topic. This is the course where you get credit points by building some of the most advanced exploits on the planet! The luckiest team will collect a Best Demo Award at the end of the course.</td>
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<tr>
<td>Literature</td>
<td>Slides, relevant literature and manuals will be made available during the course. Experience with Linux, systems programming and computer architecture.</td>
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<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
<tr>
<td>Abstract</td>
<td>Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects. Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data. The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data. Topics covered in the lecture include: Fundamentals: What is data? Bayesian Learning Computational learning theory Supervised learning: Ensembles: Bagging and Boosting Max Margin methods Neural networks Unsupervised learning: Dimensionality reduction techniques Clustering Mixture Models Non-parametric density estimation Learning Dynamical Systems</td>
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<tr>
<td>Lecture notes</td>
<td>No lecture notes, but slides will be made available on the course webpage.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least &quot;Introduction to Machine Learning&quot; or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.</td>
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<tr>
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<th>Lecturers</th>
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</thead>
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<tr>
<td>252-3005-00L</td>
<td>Natural Language Processing</td>
<td>W</td>
<td>7</td>
<td>3V+3U+1A</td>
<td>R. Cotterell</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems. The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1309 of 2416
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations. In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.


Number of participants limited to 320.

For solving assignments, some programming experience in Python is expected.

For students to the latest and most exciting research in the space.

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

More information here: https://las.inf.ethz.ch/teaching/pai-f18

While the course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although there will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.

While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

- For solving assignments, some programming experience in Python is expected.
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).
The course will be centered around exploring methodological and system-focused perspectives on designing AI systems for education and analyzing educational data using AI methods. Students will be expected to a) engage in presentations and active in-class and asynchronous discussions, and b) work on problem-sets exemplifying the use of educational data mining techniques.

**Content**

The course will start with an introduction to data mining techniques (e.g., prediction, structured discovery, visualization, and relationship mining) relevant to analyzing educational data. We will then continue with topics on personalization in AI in educational technologies (e.g., learner modeling and knowledge tracing, self-improving AIED systems) while showcasing exemplary applications in areas such as content creation and dialog-based tutoring. Finally, we will cover ethical challenges associated with using AI in student-facing settings. Face-to-face meetings will be held every fortnight, although students will be expected to work individually on weekly tasks (e.g., discussing relevant literature, working on problems, preparing seminar presentations).

**Lecture notes**

Lecture slides will be made available at the course Web site.

**Literature**

No textbook is required, but there will be regularly assigned readings from research literature, linked to the course website.

**Prerequisites / notice**

There are no prerequisites for this class. However, it will help if the student has taken an undergraduate or graduate level class in statistics, data science or machine learning. This class is appropriate for advanced undergraduates and master students in Computer Science as well as PhD students in other departments.

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**Course Code:** 263-5210-00L  
**Course Title:** Probabilistic Artificial Intelligence  
**Credit Points:** W 8 credits 3V+2U+2A  
**Objective:**  
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Content**

Topics covered:
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Bayesian deep learning)
- Reinforcement learning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming. The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

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**Course Code:** 263-5255-00L  
**Course Title:** Foundations of Reinforcement Learning  
**Credit Points:** W 5 credits 2V+2A  
**Objective:**  
This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

**Content**

- Generalize or discover “new” applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Develop policies for Markov decision processes, approximate dynamic programming, artificial intelligence, and optimization.

**Prerequisites / notice**

Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

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**Course Code:** 263-5300-00L  
**Course Title:** Guarantees for Machine Learning  
**Credit Points:** W 7 credits 3V+1U+2A  
**Objective:**  
By the end of the semester, students should be able to:
- Understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work.
- Critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions.
- Outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in-person exercises, homeworks and potentially in the final project.
- Effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

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**Course Details:**  
- Autumn Semester 2022  
- Number of participants limited to 30.

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**Course Details:**  
- Autumn Semester 2022  
- Number of participants limited to 190.

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- Autumn Semester 2022  
- Number of participants limited to 30.

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- Autumn Semester 2022  
- Number of participants limited to 190.

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- Autumn Semester 2022  
- Number of participants limited to 30.

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**Course Details:**  
- Autumn Semester 2022  
- Number of participants limited to 190.
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites / notice
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression", "Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<td>assessed</td>
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Literature
The literature will be provided by the instructors on the class website.

>>> Minor in Networking

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>252-1411-00L</td>
<td>Security of Wireless Networks</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U+2A</td>
<td>S. Capkun, K. Kostiainen</td>
</tr>
<tr>
<td>Abstract</td>
<td>Core Elements: Wireless communication channel, Wireless network architectures and protocols, Attacks on wireless networks, Protection techniques.</td>
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</tr>
<tr>
<td>Objective</td>
<td>After this course, the students should be able to: describe and classify security goals and attacks in wireless networks; describe security architectures of the following wireless systems and networks: 802.11, GSM/UMTS, RFID, ad hoc/sensor networks; reason about security protocols for wireless network; implement mechanisms to secure 802.11 networks.</td>
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</table>

| 263-4640-00L | Network Security | W    | 8 credits | 2V+2U+3A | A. Perrig, S. Frei, M. Legner, K. Paterson |
| Abstract    | Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them. |
| Objective   | - Students are familiar with fundamental network-security concepts. |
|            | - Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures. |
|            | - Students can identify and assess vulnerabilities in software systems and network protocols. |
|            | - Students have an in-depth understanding of a range of important state-of-the-art security technologies. |
|            | - Students can implement network-security protocols based on cryptographic libraries. |
| Content    | The course will cover topics spanning four broad themes with a focus on the first two themes: (1) network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems; (2) network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks; (3) analysis and inference topics such as traffic monitoring and network forensics; and (4) new technologies related to next-generation networks. |
| Prerequisites / notice | In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics. |

This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course. The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.
Advanced Topics in Communication Networks

**Abstract**
This course covers advanced topics and technologies in computer networks, both theoretically and practically. It is offered each Fall semester, with rotating topics. Repetition for credit is possible with consent of the instructor. In the next edition, the course will cover advanced topics in Internet routing and forwarding.

**Objective**
The goals of this course is to provide students with a deeper understanding of the existing and upcoming Internet routing and forwarding technologies used in large-scale computer networks such as Internet Service Providers (e.g., Swisscom or Deutsche Telekom), Content Delivery Networks (e.g., Netflix) and Data Centers (e.g., Google). Besides covering the fundamentals, the course will be "hands-on" and will enable students to play with the technologies in realistic network environments, and even implement some of them on their own during labs and a final group project.

**Content**
The course will cover advanced topics in Internet routing and forwarding such as:

- Tunneling
- Hierarchical routing
- Traffic Engineering and Load Balancing
- Virtual Private Networks
- Quality of Service/Queuing/Scheduling
- Fast Convergence
- Network virtualization
- Network programmability (OpenFlow, P4)
- Network measurements

The course will be divided in two main blocks. The first block (~8 weeks) will interleave classical lectures with practical exercises and labs. The second block (~6 weeks) will consist of a practical project which will be performed in small groups (~3 students). During the second block, lecture slots will be replaced by feedback sessions where students will be able to ask questions and get feedback about their project. The last week of the semester will be dedicated to student presentations and demonstrations.

**Lecture notes**
Lecture notes and material will be made available before each course on the course website.

**Literature**
Relevant references will be made available through the course website.

**Prerequisites / notice**
Prerequisites: Communication Networks (227-0120-00L) or equivalents / good programming skills (in any language) are expected as both the exercises and the final project will involve coding.

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**Minor in Programming Languages and Software Engineering**

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<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>252-0237-00L</td>
<td>Concepts of Object-Oriented Programming</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>P. Müller</td>
</tr>
</tbody>
</table>

**Abstract**
Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection

**Objective**
After this course, students will:
- Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features.
- Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs.
- Be able to learn new languages more rapidly.
- Be aware of many subtle problems of object-oriented programming and know how to avoid them.
The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how important challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:
- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing).
- The key problems of single and multiple inheritance and how different languages address them.
- Generic type systems, in particular, Java generics, C# generics, and C++ templates.
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them.
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing.
- How to maintain the consistency of data structures.

Will be announced in the lecture.

The course is split into 3 parts:

1. **Reliable and Trustworthy Artificial Intelligence**
   - **W**: 6 credits
   - **ECTS**: 2V+2U+1A
   - **M. Vechev**

   **Abstract**: Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

   **Objective**: Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

   **Content**: The course is split into 3 parts:
   - Robustness in Deep Learning
   - Privacy of Machine Learning
   - Fairness of Machine Learning

   - Adversarial attacks and defenses on deep learning models.
   - Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
   - Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

   - Threat models (e.g., stealing data, poisoning, membership inference, etc.).
   - Attacking federated machine learning (across modalities such as vision, natural language and tabular) .
   - Differential privacy for defending machine learning.
   - Enforcing regulations with guarantees (e.g., via provable data minimization).

2. **Design of Parallel and High-Performance Computing**
   - **W**: 9 credits
   - **ECTS**: 3V+2U+3A
   - **T. Hoefler, M. Püschel**

   **Abstract**: Advanced topics in parallel and high-performance computing. Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore. More information here: https://www.sri.inf.ethz.ch/teaching/rtai22.

   **Objective**: For solving assignments, some programming experience in Python is expected.

   **Prerequisites / notice**
   - Introduction to fairness (motivation, definitions).
   - Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
   - Enforcing group fairness with guarantees.

3. **System Security**
   - **W**: 7 credits
   - **ECTS**: 2V+2U+2A
   - **S. Capkun, S. Shinde**

   **Abstract**: The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.

Content
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

263-2800-00L  Design of Parallel and High-Performance Computing  W  9 credits  3V+2U+3A  T. Hoefler, M. Püschel

Number of participants limited to 125.

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

263-3845-00L  Data Management Systems  W  8 credits  3V+1U+3A  G. Alonso

Abstract
The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective
The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation versus interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content
The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature
The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

Prerequisites / notice
The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

263-3850-00L  Informal Methods  W  5 credits  2G+2A  D. Cock

Abstract
Formal methods are increasingly a key part of the methodological toolkit of systems programmers - those writing operating systems, databases, and distributed systems. This course is about how to apply concepts, techniques, and principles from formal methods to such software systems, and how to get into the habit of thinking formally about systems design even when writing low-level C code.

Objective
This course is about equipping students whose focus is with the insights and conceptual tools provided by formal methods, and thereby enabling them to become better systems programmers.

By the end of the course, students should be able to seamlessly integrate basic concepts form formal methods into how they conceive, design, implement, reason about, and debug computer systems.

Content
The goal is not to provide a comprehensive introduction to formal methods - this is well covered by other courses in the department. Instead, it is intended to provide students in computer systems (who may or may not have existing background knowledge of formal methods) with a basis for applying formal methods in their work.

Instead, the majority of the course will be about how to apply these techniques to actual, practical code in real systems. We will work from real systems code written both by students taking the course, and practical systems developed using formal techniques, in particular the verified sel4 microkernel will be a key case study. We will also focus on informal, pen-and-paper arguments for correctness of programs and systems rather than using theorem provers or automated verification tools; again these latter techniques are well covered in other courses (and recommended as a complement to this one).

Minor in Theoretical Computer Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0417-00L</td>
<td>Information Theory I</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>A. Lapidoth</td>
</tr>
</tbody>
</table>

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content
The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

252-0417-00L  Randomized Algorithms and Probabilistic Methods  W  10 credits  3V+2U+4A  A. Steger

Number of participants limited to 125.

Abstract
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

Content
We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

Prerequisites / notice
This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

Number of participants limited to 125.

Abstract
Advanced topics in parallel and high-performance computing.

Objective
Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

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Number of participants limited to 125.
Abstract
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

Objective
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes
Yes

Literature

252-0535-00L Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals: What is data? Bayesian Learning
- Computational learning theory
- Supervised learning: Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks
- Unsupervised learning: Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-1425-00L Geometry: Combinatorics and Algorithms

Abstract
Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

Objective
The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Content
Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in R^d, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Lecture notes
yes

Literature

Prerequisites / notice
Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.
Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

263-5300-00L Guarantees for Machine Learning

Number of participants limited to 30.

Abstract
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Objective
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes
Yes.

Literature

252-0535-00L Advanced Machine Learning

Abstract
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals: What is data? Bayesian Learning
- Computational learning theory
- Supervised learning: Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks
- Unsupervised learning: Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-1425-00L Geometry: Combinatorics and Algorithms

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Geometric structures are useful in many areas, and there is a need to understand their structural properties, and to work with them algorithmically. The lecture addresses theoretical foundations concerning geometric structures. Central objects of interest are triangulations. We study combinatorial (Does a certain object exist?) and algorithmic questions (Can we find a certain object efficiently?)

Objective
The goal is to make students familiar with fundamental concepts, techniques and results in combinatorial and computational geometry, so as to enable them to model, analyze, and solve theoretical and practical problems in the area and in various application domains. In particular, we want to prepare students for conducting independent research, for instance, within the scope of a thesis project.

Content
Planar and geometric graphs, embeddings and their representation (Whitney's Theorem, canonical orderings, DCEL), polygon triangulations and the art gallery theorem, convexity in R^d, planar convex hull algorithms (Jarvis Wrap, Graham Scan, Chan's Algorithm), point set triangulations, Delaunay triangulations (Lawson flips, lifting map, randomized incremental construction), Voronoi diagrams, the Crossing Lemma and incidence bounds, line arrangements (duality, Zone Theorem, ham-sandwich cuts), 3-SUM hardness, counting planar triangulations.

Lecture notes
yes

Literature

Prerequisites / notice
Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.
Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

263-5300-00L Guarantees for Machine Learning

Number of participants limited to 30.
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

**Content**

This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current ML research that aims to understand modern phenomena in machine learning, including but not limited to

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

**Prerequisites / notice**

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression” / “Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

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**401-3054-14L Probabilistic Methods in Combinatorics**

**Abstract**

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

**Content**

The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

**Literature**

**Fostered competencies**

Subject-specific Competencies: Concepts and Theories assessed
Method-specific Competencies: Analytical Competencies assessed
Social Competencies: Communication assessed
Personal Competencies: Creative Thinking assessed

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**401-3055-64L Algebraic Methods in Combinatorics**

**Abstract**

Algebraic combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

**Objective**

The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

**Content**

Algebraic combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure $A$ one maps its elements to vectors in a linear space, and shows that the set $A$ is mapped to linearly independent vectors. It then follows that the cardinality of $A$ is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvectors of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

**Lecture notes**

Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.
The objective of this course is to learn how to solve algorithmic problems given by a textual description. This includes appropriate problem setting, finding appropriate combinatorial optimization problems and polyhedral techniques; and equivalence between optimization and separation.

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

The course is organised in two-week segments. In each segment, a new concept from Information Security will be introduced. The overall scope will be broad, including cryptography, protocol design, network security, system security.

Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Literature

- F. Tramèr, D. Hofheinz, A. Perrig, S. Shinde, E. Welzl
- Paul C. van Oorschot, Computer Security and the Internet: Tools and Jewels.
- Dan Boneh and Victor Shoup, A Graduate Course in Applied Cryptography.
- K. Paterson
- Equivalence between optimization and separation.
- Combinatorial optimization problems and polyhedral techniques;
- Flows and cuts;
- Linear programming and polyhedra;
- Equivalence between optimization and separation.
Abstract
This course gives an overview about wireless standards and summarizes the state of art for Wi-Fi 802.11, Cellular 5G, and Internet-of-Things, contact tracing with Bluetooth, audio communication, visible light communications, medical technology. The course combines lectures with a set of assignments in which students are asked to work with a JAVA simulation tool, and Arduino boards.

Objective
The objective of the course is to learn about the general principles of wireless communications, including physics, frequency spectrum regulation, and standards. Further, the most up-to-date standards and protocols used for wireless LAN IEEE 802.11, Wi-Fi, Internet-of-Things, sensor networks, cellular networks, visible light communication, and cognitive radios, are analyzed and evaluated. Students develop their own add-on mobile computing algorithms to improve the behavior of the systems, using a Java-based event-driven simulator. We also hand out embedded systems that can be used for experiments for optical communication. Throughout the course, insights from telecommunications, toy industry, and medical technology industry are shared.

Content
Wireless Communication, Wi-Fi, Contact Tracing, Bluetooth, Internet-of-Things, 5G, Standards, Regulation, Algorithms, Radio Spectrum, Cognitive Radio, Mesh Networks, Optical Communication, Visible Light Communication. We will address contact tracing, radio link budget, location distance measurements, and Bluetooth in more depth. MedTech basics are also provided.

Chapters:
1 Introduction
2 Wireless Communication Basics
3 IEEE 802.11 Wireless LAN (Wi-Fi)
4 IEEE 802.15 Wireless PAN (ZigBee & Bluetooth)
5 Mobile Computing Algorithm Basics: Control and Game Theory
6 Visible Light Communication
7 Audio Communication
8 Cellular Networking Basics (LTE, 5G, Internet-of-Things)
9 Mobile Computing for Automated Medicine Delivery
10 Cognitive Radio, Delay Tolerant Networking, Radio Spectrum Sharing

Lecture notes
The course material will be made available by the lecturer.

Literature
(1) The course webpage (look for Stefan Mangold’s site)
(2) The Java 802 protocol emulator “JEmula802” from https://bitbucket.org/lfield/jemula802

Prerequisites / notice
Students should have interest in wireless communication, and should be familiar with Java programming. Experience with GNU Octave or Matlab will help too (not required).

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Research in Computer Science
263-0600-00L
W 5 credits
11A
Professors

Abstract
Independent project work under the supervision of a Computer Science Professor.

Objective
Independent project work under the supervision of a Computer Science Professor.

Prerequisites / notice
Only students who fulfill one of the following requirements are allowed to begin a research project:

a) 1 lab (interfocus course) and 1 focus course
b) 2 core focus courses
c) 2 labs (interfocus courses)

A task description must be submitted to the Student Administration Office at the beginning of the work.

Technology Investing
263-5053-00L
W 2 credits
A. Ilic, C. Jurytko, A. Lidberg

Abstract
Technology has the potential to transform our society. But without the right team & funding, some break-throughs will never see the light of day. This seminar helps aspiring student/research entrepreneurs to understand how to fund their path from research into practice. The examples and cases will be primarily from software, AI, and other deep-tech ventures.

Objective
After attending this course, students will be able to:
- Explain the differences between VC and founder thinking
- Evaluate if a start-up is suited for venture capital (“VC readiness”)
- Evaluate founder friendliness of term sheets
- Determine funding needs & strategy for a start-up from research to first round
- Write and evaluate an investment memo
The course is practically oriented and features guest speakers from leading venture capital firms and start-ups. The course embraces a unique perspective combining technology and investor thinking. The seminar is structured around five days with the following themes:

- The macro picture. Why does venture capital exist? What are major tech break-through areas and their disruptive potential? We also review the differences in the US and European perspective as well as developments towards more impact and diversity conscious funds.

- A peek into the mind of a VC. How to build a successful VC? Learn what key factors & processes required to build a successful venture capital company. This includes strategic decisions for investment thesis, structure of a fund, portfolio economics, valuation & ownership targets, cap table. In addition, we introduce the fundamentals of the investment process (including due diligence, term sheets, and deal memo) as well as portfolio management.

- The founder’s perspective. Why should you raise venture capital and how? Learn to evaluate the founder friendliness of terms, company approach, strategic decisions, negotiation and valuation.

- Fundraising types. Learn about different types of funding and their implications. This includes an overview of the Swiss ecosystem and a discussion of the different types (grants, equity, loans, SAFE, crowd, ...). We also include a practical session on crypto technology for modern fund-raising using launchpads and tokenized shares.

Tying it all together. The last day is focused on simulating an investment committee meeting where the groups present their deal memos and discuss with the audience.

263-5054-00L Patenting Digital Innovations W 1 credit 2S A. Illic, B. Best

Number of participants limited to 50.

### Abstract
In this seminar dedicated to digital innovations, we will bust the most stubborn myths around AI software patents such as “Software/AI isn’t patentable”, “AI patents are useless because you can’t figure out if they are infringed”, and many others. We will look at how AI and software start-ups can use patents to create a strong IP position in a scalable way.

### Objective
After attending this course, students will be able to:
- Understand the basics of patenting in the digital space relevant for a global market
- Evaluate patenting opportunities with a more differentiated view on the topic
- Effectively use patents as a cost-effective part of a technology startup’s business plan
- Conduct patent searches, freedom-to-operate analysis and infringement analyses
- Write their first software/AI-related invention disclosure suitable for patenting

### Content
The course is focused on patenting digital innovations. It is designed for students with entrepreneurial interests that like to get a hands-on perspective on the topic of intellectual property strategies and patents.

The seminar includes presentations and practical group exercises to apply the acquired knowledge in practice. Entrepreneurs and leading IP experts are joining the seminar as guest speakers for discussion of real-life examples.

Topics that will be covered include:
- Best practices that any AI/software startups should know about IP and patents
- How investors evaluate a strong IP situation of a startup
- How to efficiently monitor competitor patent activity and obtain “FTO”
- How to create an effective patent filing strategy that grows with the business
- How to efficiently create AI patents while not getting distracted from the founder’s core business

The course also contains a group work of a “FTO battle” where two teams compete in a freedom-to-operate analysis and individual work to write their first invention disclosure related to an AI or software topic.

227-2210-00L Computer Architecture W 8 credits 6G+1A O. Mutlu

### Abstract
Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers basic components of a modern computing system (memory, processors, interconnects, accelerators). The course takes a hardware/software cooperative approach to understanding and designing computing systems.

### Objective
We will learn the fundamental concepts of the different parts of modern computing systems, as well as the latest major research topics in Industry and Academia. We will extensively cover memory systems (including DRAM and new Non-Volatile Memory technologies, memory controllers, flash memory), new paradigms like processing-in-memory, parallel computing systems (including multicore processors, coherence and consistency, GPUs), heterogeneous computing, interconnection networks, specialized systems for major data-intensive workloads (e.g. graph analytics, bioinformatics, machine learning), etc. We will focus on fundamentals as well as cutting-edge research. Significant attention will be given to real-life examples and tradeoffs, as well as critical analysis of modern computing systems.

### Content
The principles presented in the lecture are reinforced in the laboratory through 1) the design and implementation of a cycle-accurate simulator, where we will explore different components of a modern computing system (e.g., pipeline, memory hierarchy, branch prediction, prefetching, caches, multithreading), and 2) the extension of state-of-the-art research simulators (e.g., Ramulator) for more in-depth understanding of specific system components (e.g., memory scheduling, prefetching).

### Lecture notes
All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/architecture.

### Literature
See https://safari.ethz.ch/architecture for past examples.

### Prerequisites / notice

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**Science in Perspective**

*Note that no more than six credits can be accredited in this category.*

see Science in Perspective: Type A: Enhancement of Reflection Capability
### Master's Thesis

**Number** 263-0800-00L  
**Title** Master's Thesis

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling any additional requirements necessary to gain admission to the master programme;
- c. "Inter focus courses" (16 credits) completed;
- d. "Focus courses" (26 credits) completed, from which at least 16 credits must come from the Major Core courses;
- e. "Practical work" at least 8 credits completed.

**Abstract**  
The Master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

**Objective**  
To work independently and to produce a scientifically structured work under the supervision of a Computer Science Professor.

**Content**  
Independent project work supervised by a Computer Science professor. Duration 6 months.

**Prerequisites / notice**  
Supervisor must be a professor at D-INFK or affiliated, see https://inf.ethz.ch/people/faculty.html

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**Computer Science Master - Key for Type**

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**Key for Hours**

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**ECTS**  
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
This course gives an introduction to the following subjects:

1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

In the course “Energy Conversion”, the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

### Content

1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
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7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

### Literature

- **Tom M. Apostol, Calculus, Volume 1, One-Variable Calculus with an Introduction to Linear Algebra, 2nd Edition**, Wiley
- **Serge Lang, A First Course in Calculus, 5th edition**, Springer New York
- **Serge Lang, Introduction to Linear Algebra, 2nd edition**, Springer New York
- **Ulrich L. Rohde, Introduction to integral calculus : Systematic studies with engineering applications for beginners**, Wiley.

### Prerequisites and notice

This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.
Objective

Participants will come to understand how they can best navigate the design and building process, especially in relation to understanding their profession, gaining a thorough knowledge of rules and regulations, as well as understanding how involved parties’ minds work. They will also have the opportunity to investigate ways in which they can relate to, understand, and best respond to their clients’ wants and needs. Finally, course participants will come to appreciate the various tools and instruments, which are available to them when implementing their projects. The course will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship.

Content

“Design and Building Process MIBS” is a brief manual for prospective architects and engineers covering the competencies and the responsibilities of involved parties through the design and building process. Twelve compact aspects regarding the establish building culture are gaining importance in an increasingly specialised, complex and international surrounding. Lectures on the topics of profession, service model, organisation, project, design quality, coordination, costing, tendering and construction management, contracts and agreements, life cycle, real estate market, and getting started will guide the participants, bringing the individual pieces of knowledge into a superordinate relationship. The course introduces the key figures, depicts the criteria of the project and highlights the provided services of the consultants. In addition to discussing the basics, the terminologies and the tendencies, the lecture units will refer to the studios as well as the practice: Teaching-based case studies will complement and deepen the understanding of the twelve selected aspects. The course is presented as a moderated seminar to allow students the opportunity for individual input: active collaboration between the students and their tutor therefore required.

Lecture notes

The recordings of the lectures are available on the MAP under the link https://map.arch.ethz.ch (book symbol at the top right).

Literature

https://map.arch.ethz.ch

ITA Pool - information event on the courses offered at the institute ITA: Wednesday 8th September 2021, 10-11 h, ONLINE.

ZoomLink: https://ethz.zoom.us/j/66588100789

103-0317-00L Spatial Planning and Development

W 3 credits 2G D. Kaufmann, A. Kuizenbrouwer

Only for master students, otherwise a special permission by the lecturer is required.

Abstract

The course deals with important theoretical, material and methodical foundations for action and decision-making of spatial relevance. This course discusses central tasks and possible solutions for current and future challenges of spatial development in Switzerland and Europe.

Objective

Spatial development deals with the development, formation and arrangement of our environment. In order to be able to mediate between the different demands, interests and projects of multiple actors, a forward-looking, action-oriented and robust planning is necessary. It is committed - in the sense of a sustainable spatial development - to the economical handling of resources, in particular of the non-replicable resource soil.

The lecture introduces necessary basic knowledge and is based on the following main topics:

- Inward development and challenges of spatial transformation
- Planning approaches and The (political) steering of spatial development
- Interplay of formal and informal processes and processes across different scales of spatial development
- Methods of action-oriented planning in situations of insecurity
- Integrated space and infrastructure development
- Different types of participation in spatial development

By taking up the lecture, the students are able to recognize cross-scale, complex tasks of spatial development and transformation and to use their theoretical, methodical and professional knowledge to clarify them.

Content

- Planning approaches and political organization in Switzerland
- Tasks of spatial relevance
- Key figures and ratios
- Drivers of spatial development
- Steering spatial development I: Policy
  - Steering spatial development II : Formal and informal instruments
- Organizing spatial development I: Governance
- Organizing spatial development II: Processes and organization
- Methods in spatial planning I
- Methods in spatial planning II
- Planning in complex situations
- Participation in spatial development
- Present and future core tasks of spatial development

Lecture notes

Further information and the documents for the lecture can be found on Moodle

https://moodle-app2.let.ethz.ch/course/view.php?id=18389

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Core Courses

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<td>Materials and Constructions</td>
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<td>G. Habert, M. Posani</td>
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Abstract

Building materials with a special focus on regenerative materials: earth, bio-based and reuse. Sourcing, properties and performance, building envelope integration and detailing, sustainable building construction

Objective

The students will acquire knowledge in the following fields:

- Fundamentals of material performance
- Introduction to durability problems of building facades
- Materials for the building envelope:
  - Overview of structural materials and systems: concrete, steel, wood and bamboo, earth
  - Insulating materials (bio-based vs conventional)
  - Air barrier, vapour barrier and sealants
- Interior finishing
- Assessment of materials and components behaviour and performance
- Solutions for energy retrofitting of (historical) buildings

Aspects of sustainability and durability
Building Physics: Theory and Applications
Enrolment after the lecturer only.

Objective
The students will acquire in the following fields:
- Indoor and outdoor climate and driving forces.
- Hygrothermal properties of building materials.
- Building envelope solutions and their construction.
- Hygrothermal performance and durability.

Content
Principles of heat and mass transport, hygro-thermal performance, durability of the building envelope and interaction with indoor and outdoor climates, applications.

Lecture notes
Handouts, supporting material and exercises are provided online via Moodle.

Technology and Innovation Management

Abstract
This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

Objective
This course intends to enable all students to:
- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

Content
This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics

Principles of Microeconomics

Objective
The learning objectives of the course are:
(1) Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.

Content
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.
Literature

N. Gregory Mankiw and Mark P. Taylor (2020), "Economics", 5th edition, South-Western Cengage Learning. The book can also be used for the course 'Principles of Macroeconomics' (Sturm)

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book: N. Gregory Mankiw and Mark P. Taylor (2020), "Microeconomics", 5th edition, South-Western Cengage Learning.

Prerequisites / notice

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Fostered competencies

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066-0423-00L Application of CFD in Buildings

W 3 credits 3V D. Lakehal

Abstract

Fundamentals, Applications and Project works in the area of CFD in buildings.

Objective

I- Understanding:
- Basic principles of fluid flow & heat transfer
- Basic concepts of CFD
- Validation and verification, practical guidelines

II- Application and project works of CFD in buildings. Use of the CFD software www.transat-cfd.com only, which is installed in the computer room of the Archi. Department.

Students will have two projects:

1- Group projects: Beginning of Nov. Projects will be assigned by the tutors to the students organized in groups of 2. Projects will include canonical problems in two dimensions essentially. A report is to be handed out end of Nov.

2- Individual Projects: 2nd week of Nov. to Christmas. These are individual projects, chosen by students from the list of items below.

NOTE:
Students enrolled in the 'Integrated Design Project' course can use their Individual Project (this class) for their IDP project, provided (1) they attend this course (CFD in Buildings) and use the CFD code TransAT to benefit the support of the tutors.

Content

I. Fundamentals
- Basic principles of fluid flow & heat transfer
- Laminar versus turbulent flow
- Forced vs. natural convection
- Basic concepts of CFD (Discretization, schemes, solvers, etc.)
- Turbulence modelling
- Near-wall treatment
- Validation and verification, practical guidelines

II. Application of CFD for real problems including (Projects):

1. Wind – Urban Scale: students would use the building shape to determine locations for wind inlets and outlets based on façade pressures.
2. Wind – Cross-ventilation: using the interior shape of a building with inlets and outlets to determine flow rates
3. Stack effect: on a windless day with people in the building, how much airflow would be anticipated airflow rate given inlets and outlets
4. Wind & heat removal: Given inlets and outlets with people in the building, how much heat is removed from the building
5. Solar chimney: given a building with a chimney, how much extra airflow is created if the chimney is solar (absorbs radiation) vs. typical (not designed to absorb radiation)
6. Plant/vegetation effects: Given a building with a courtyard, how much is cross-ventilation affected by including plants vs. not having plants or how will the plants affect stack venting.
7. Air pollution and contaminant dispersion

Lecture notes

Material (pdf files) will be sent to the students before the start of the course.
### Literature
We will update the material in due time.

Use cases done in part by your colleagues in this class, from year 2015 on:

Main reference for fluid mechanics:
J.H. Spurk, Fluid Mechanics, Springer

Main reference for CFD: Ferziger and Peric, Computational Methods for Fluid Mechanics, Springer

Main Wiki reference:

Other useful papers:

### Fostered competencies

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### Abstract
Urban physics: wind, wind comfort, pollutant dispersion, natural ventilation, driving rain, heat islands, climate change and weather conditions, urban acoustics and energy use in the urban context.

### Objective
- Basic knowledge of the global climate and the local microclimate around buildings
- Impact of urban environment on wind, ventilation, rain, pollutants, acoustics and energy, and their relation to comfort, durability, air quality and energy demand
- Application of urban physics concepts in urban design

### Content
- Climate Change. The Global Picture: global energy balance, global climate models, the IPCC process. Towards regional climate scenarios: role of spatial resolution, overview of approaches, hydrostatic RCMs, cloud-resolving RCMs
- Urban micro climate and comfort: urban heat island effect, wind flow and radiation in the built environment, convective heat transport modelling, heat balance and ventilation of urban spaces - impact of morphology, outdoor wind comfort, outdoor thermal comfort,
- Urban energy and urban design. Energy performance of building quarters and cities, decentralized urban energy production and storage technologies, district heating networks, optimization of energy consumption at district level, effect of the micro climate, urban heat islands, and climate change on the energy performance of buildings and building blocks.
- Wind driving rain (WDR): WDR phenomena, WDR experimental and modeling, wind blocking effect, applications and moisture durability
- Pollutant dispersion, pollutant cycle: emission, transport and deposition, air quality
- Urban acoustics. noise propagation through the urban environment, meteorological effects, urban acoustic modeling, noise reduction measures, urban vegetation
- Practical exercise on climatic data collection and analyze

### Lecture notes
The course lectures and material are provided online via Moodle.

### Prerequisites / notice
For MiBS Master students 151-8011-ooL Building Physics Theory & Application is a pre-requisite for this course or instructor permission. For others no prior knowledge is required.

066-0421-00L Building Systems I O 3 credits 3G I. Hischier, L. Baldini, F. Khayatian, A. Schlüter, M. Sulzer

### Abstract
Building Systems I gives an overview of fundamentals and concepts relevant for the design of building systems.

### Objective
- Knowledge of the fundamentals, principles and technologies for building heating, cooling, ventilation and electricity supply.
- Knowledge of the integration and interdependencies of building systems and building structure, construction and aesthetics
- Ability to estimate relevant quantities and qualities for heating/cooling/ventilation/electricity of buildings and the related supply systems
- Ability to evaluate and choose an approach for sustainable heating/cooling/ventilation/electricity, the system and its components
- Synthesis in own integrated design projects

### Content
1. Comfort & Environment
2. Heating / cooling concepts and demand
3. Natural / mechanical ventilation concepts and demand
4. Solar generation / electricity storage and demand
5. Information & Communication Technologies

101-0608-00L Design-Integrated Life Cycle Assessment W 3 credits 2G G. Habert, A. Galimshina

### Abstract
Currently, Life Cycle Assessment (LCA) is applied as an ex-post design evaluation of buildings, but rarely used to improve the building during the design process.

The aim of this course is to apply LCA during the design of buildings by means of a digital, parametric tool. The necessary fundamentals of the LCA method will be taught following a lecture on demands approach.

### Objective
- Know the methodology of LCA
- Be able to apply LCA in the design process to assess and improve the environmental performance of their projects
- Be able to use the parametric LCA tool and link it to additional performance assessment tools for a holistic optimisation
The course will be structured into two parts, each making up about half of the semester.

Part I: Exercises with lectures on demand
The first six individual courses will follow the "lectures on demand" approach. Small "hands-on" exercises focusing on one specific aspect will be given out and the necessary background knowledge will be provided in the form of short input lectures when questions arise. The following topics will be discussed during the first part:
1) LCA basic introduction
2) System boundaries, functional unit, end of life
3) Carbon budget and LCA benchmarks
4) BIM-LCA, available calculation tools and databases
5) Integrated analysis of environmental and cost assessment
6) Bio-based carbon storage

Part II: Project-based learning
In the second part, the students will work on their individual project in groups of three. For the design task, the students will bring their own project and work on improving it. The projects can be chosen depending on the students background and range from buildings to infrastructure projects. Intermediate presentations will ensure the continuous work and make sure all groups are on the same level and learn from each other. During this part, the following hands-on tutorials will be given:
1) Introduction to Rhinoceros 6 and 7
2) Introduction to grasshopper
3) Integrated assessment tools (ladybug tools)
4) Introduction to in-house grasshopper plugin for LCA analysis

Lecture notes
As the course follows a lecture on demand approach, the lecture slides will be provided after each course.

Literature
A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

Prerequisites / notice
Prerequisite: Sustainable construction (101-0577-00L). Otherwise a special permission by the lecturer is required.

The students are expected to work out of class as well. The course time will be used by the teachers to answer project-specific questions.

The lecture series will be conducted in English and is aimed at students of master's programs, particularly the departments ARCH, BAUG, ITET, MAVT, MTEC and UWIS.

No lecture will be given during Seminar week.

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### 151-0209-00L Renewable Energy Technologies

<table>
<thead>
<tr>
<th>Abstract</th>
<th>Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.</td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture Notes containing copies of the presented slides.</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.</td>
</tr>
</tbody>
</table>

### 101-0123-00L Structural Design

<table>
<thead>
<tr>
<th>Abstract</th>
<th>The goal of the course is to introduce the civil engineering students to Structural Design, which is regarded as a discipline that relates structural behavior, construction technologies and architectural concepts. The course encourages the students to understand the relationship between the form of a structure and the forces within it by promoting the development of designed projects.</th>
</tr>
</thead>
</table>
| Objective | After successfully completing this course the students will be able to:  
1. Critically question structural design concepts of historical and contemporary references  
2. Use graphic statics and strut-and-tie models based on the Theory of Plasticity to describe the load bearing behavior of structures  
3. Understand different construction technologies and have an awareness of their potential for structural design  
4. Use contemporary digital tools for the design of structures in equilibrium  
5. Design an appropriate structural system for a given design task taking into account architectural considerations |
| Content | The goal of the course is to introduce the civil engineering students to Structural Design, which is understood as a discipline that relates structural behavior, construction technologies and architectural concepts. Hence, the course encourages the students to develop an intuitive understanding of the relationship between the form of a structure and the forces within it by promoting the development of designed projects, in which the static and architectural aspects come together. The course is structured in two main parts, each developed in half of a semester: a mainly theoretical one (including the teaching of graphic statics) and a mainly applied one (focused on the development of a design project by the students using digital form-finding tools). |
| Theory | Graphic statics is a graphical method developed by Prof. Karl Culmann and firstly published in 1864 at ETH Zurich. In this approach to structural analysis and design, geometric construction techniques are used to visualize the relation between the geometry of a structure and the forces acting in and on it, represented by geometrically dependent form and force diagrams. The course will firstly review the main principles of graphic statics through a series of frontal lectures and discuss the relationship to analytical statics. Graphic statics is then used as an operative tool to design structures in equilibrium based on the lower bound theorem of the Theory of Plasticity. Additionally, the course will introduce contemporary methodologies and tools (parametric CAD software) for the interactive application of equilibrium modelling in the form of short workshops. The students will familiarize with the topic by solving exercises and confronting themselves with simple design tasks. |
| Design Project | Specific structural design approaches and design methodologies based on graphic statics and references from construction history will be introduced to the students by means of seminars and workshops. By developing a design project, the students will apply these concepts and techniques in order to become proficient with open design tasks (such as the design of a bridge, a large span hall or a tower). At the end of the semester, the students present their projects to a jury of internal and external critics in a final review. The main criterion of evaluation is the students' ability to integrate architectural considerations into their structural design. |
| Literature | "Faustformel Tragwerksentwurf" (Philippe Block, Christoph Gengangel, Stefan Peters, DVA Deutsche Verlags-Anstalt 2015, ISBN 978-3-421-04012-1)  

### 151-0909-00L Chemistry

| Abstract | This is a general chemistry course aimed at first-year bachelor students in the Department of Mechanical and Process Engineering. |

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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1327 of 2416
Objective
The aims of the course are:
1) To provide a thorough understanding of the basic principles of chemistry and its application,
2) To develop an understanding of the atomic and molecular nature of matter and of the chemical reactions that describe its transformations, and
3) To emphasize areas considered most relevant in an engineering context.

Content
Electronic structure of atoms, chemical bonding, molecular geometry and bonding theories, intermolecular forces, gases, thermodynamics, chemical thermodynamics, chemical kinetics, equilibria, liquids and solutions, acids and bases, redox- and electrochemistry.

Lecture notes
The instructor's lecture notes will be available prior to every lecture and can be downloaded from Moodle.

Literature

Specialised Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0103-00L</td>
<td>Fluid Dynamics II</td>
<td>W</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Jenny</td>
</tr>
<tr>
<td>Objective</td>
<td>Expand basic knowledge of fluid dynamics. Concepts, phenomena and quantitative description of irrotational (potential), rotational, and one-dimensional compressible flows.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture notes are available (in German). (See also info on literature below.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Relevant chapters (corresponding to lecture notes) from the textbook</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites</td>
<td>Analysis I/II, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0647-00L</td>
<td>Introduction to Mathematical Optimization</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>D. Adjiashvili</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering. Topics covered in this course include: - Linear programming (simplex method, duality theory, shadow prices, ...). - Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...). - Modelling with mathematical optimization: applications of mathematical programming in engineering.</td>
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<tr>
<td>Objective</td>
<td>The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.</td>
<td></td>
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<tr>
<td>Content</td>
<td>Information about relevant literature will be given in the lecture.</td>
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<tr>
<td>Literature</td>
<td>Prerequisites / notice</td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0477-00L</td>
<td>Acoustics I</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>K. Heutschi</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the fundamentals of acoustics in the field of sound field calculations, measurement of acoustical events, outdoor sound propagation and room acoustics of large and small enclosures. Fundamentals of acoustics, measurement and analysis of acoustical events, anatomy and properties of the ear, outdoor sound propagation, absorption and transmission of sound, room acoustics of large and small enclosures, architectural acoustics, noise and noise control, calculation of sound fields.</td>
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<tr>
<td>Objective</td>
<td>Understanding of the basic acoustical concepts and methods. Ability to understand the technical and scientific literature. Confidence in the use of measuring instruments.</td>
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</tr>
<tr>
<td>Content</td>
<td>Yes</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>This course is meant for students who did not already attend the course &quot;Mathematical Optimization&quot;, which is a more advance lecture covering similar topics. Compared to &quot;Mathematical Optimization&quot;, this course has a stronger focus on modeling and applications.</td>
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<tr>
<td>Literature</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0577-00L</td>
<td>An Introduction to Sustainable Development in the Built Environment</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>G. Habert, D. Kaushal</td>
</tr>
<tr>
<td>Abstract</td>
<td>In 2015, the UN Conference in Paris shaped future world objectives to tackle climate change. In 2016, other political bodies made these changes more difficult to predict. What does it mean for the built environment? This course provides an introduction to the notion of sustainable development when applied to our built environment</td>
<td></td>
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</tr>
<tr>
<td>Notice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
At the end of the semester, the students have an understanding of the term of sustainable development, its history, the current political and scientific discourses and its relevance for our built environment.

In order to address current challenges of climate change mitigation and resource depletion, students will learn a holistic approach of sustainable development. Ecological, economical and social constraints will be presented and students will learn about methods for argumentation and tools for assessment (i.e. life cycle assessment).

For this purpose an overview of sustainable development is presented with an introduction to the history of sustainability and its today definition as well as the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental aspects.

The course aims to promote an integral view and understanding of sustainability and describing different spheres (social/cultural, ecological, economical, and institutional) that influence our built environment.

Students will acquire critical knowledge and understand the role of involved stakeholders, their motivations and constraints, learn how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction.

After the course students should be able to define the relevance of specific local, regional or territorial aspects to achieve coherent and applicable solutions toward sustainable development.

The course offers an environmental, socio-economic and socio-technical perspective focussing on buildings, cities and their transition to resilience with sustainable development. Students will learn on theory and application of current scientific pathways towards sustainable development.

The following topics give an overview of the themes that are to be worked on during the lecture.

- Overview on the history and emergence of sustainable development
- Overview on the current understanding and definition of sustainable development

Methods
- Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction)
- Method 2: Life Cycle Costing
- Method 3: Labels and certification

Main issues:
- Operation energy at building, urban and national scale
- Mobility and density questions
- Embodied energy for developing and developed world
- Synthesis: Transition to sustainable development

All relevant information will be online available before the lectures. For each lecture slides of the lecture will be provided.

A list of the basic literature will be offered on a specific online platform, that could be used by all students attending the lectures.

<table>
<thead>
<tr>
<th>101-0417-00L</th>
<th>Transport Planning Methods</th>
<th>W</th>
<th>6 credits</th>
<th>K. W. Axhausen</th>
</tr>
</thead>
</table>

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

Content
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Moodle platform (enrollment needed)


<table>
<thead>
<tr>
<th>363-0387-00L</th>
<th>Corporate Sustainability</th>
<th>W</th>
<th>3 credits</th>
<th>V. Hoffmann, J. Meuer, A. Nunez-Jimenez</th>
</tr>
</thead>
</table>

Objective
- Students
  - assess the limits and the potential of corporate sustainability for sustainable development
  - develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method.
  - recognize and realize opportunities through team work for corporate sustainability in a business environment
  - present strategic recommendations in teams with different output formats (tv-style debate, consultancy pitch, technology model walkthrough, campaign video)

Abstract
The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.
### Content
In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share his insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final prize session at the end of the semester.

### Lecture notes

### Literature
Lecture slides will be made available on moodle prior to lectures. Literature recommendations will be distributed during the lecture.

### Prerequisites / notice
TEACHING FORMAT / ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

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### 402-0809-01L Introduction to Computational Physics (for Civil Engineers)

<table>
<thead>
<tr>
<th>W</th>
<th>4 credits</th>
<th>2V+1U</th>
<th>A. Adelmann</th>
</tr>
</thead>
</table>

**Abstract**
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

**Objective**
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**
Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

**Lecture notes**
Lecture notes and slides are available online and will be distributed if desired.

**Literature**
Lecture recommendations and references are included in the lecture notes.

**Prerequisites / notice**
Lecture and exercise lessons in English

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### 402-0809-00L Introduction to Computational Physics

<table>
<thead>
<tr>
<th>W</th>
<th>8 credits</th>
<th>2V+2U</th>
<th>A. Adelmann</th>
</tr>
</thead>
</table>

**Abstract**
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

**Objective**
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**
Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

**Lecture notes**
Lecture notes and slides are available online and will be distributed if desired.

**Literature**
Lecture recommendations and references are included in the lecture notes.

**Prerequisites / notice**
Lecture and exercise lessons in English

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### 101-0187-00L Structural Reliability and Risk Analysis

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>S. Marelli</th>
</tr>
</thead>
</table>

**Abstract**
Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing, and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

**Objective**
The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

**Content**
Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro-codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

**Lecture notes**
The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

**Literature**
- S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

**Prerequisites / notice**
Basic course on probability theory and statistics

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Data: 01.11.2022 12:41
Autumn Semester 2022
Page 1330 of 2416
Principles of Macroeconomics

363-0565-00L

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policymakers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature

This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Workshop on Sustainable Building Certification

101-0587-00L

**W** 3 credits 2G

*Abstract*
Building labels are used to certify buildings and neighbourhoods in term of sustainability. Many different labels have been developed and can be used in Switzerland (LEED, DGNB, SNBS, Minergie, 2000-Watt-Sites). In this course the differences between the certification labels and its application on 3 emblematic case study buildings will be discussed.

*Objective*
After this course, the students are able to understand and use the different certification labels. They have a clear view of what the labels take into consideration and what they don't.

*Content*
Three buildings case study will be presented.

Different certification schemes, including LEED (American standard), DGNB (German Standard with Swiss adaptation), Label SNBS, MINERGIE-ECO and 2000-Watt-Site (Swiss standards) will be presented and explained by experts.

After this overall general presentation and in order to have a closer look to specific aspects of sustainability, students will work in groups and assess during one or two weeks this specific criteria on one of the case studies presented before. This practical hands on the label will end with a presentation and a discussion where we will highlight differences between the labels.

This alternance of working session on one specific criteria for one specific building followed by a group presentation and discussion to compare labels is repeated for the different focus point (operation energy, mobility, daylight, indoor air quality).

*Lecture notes*
The slides from the presentations will be made available.

*Literature*
All documents for certification labels as well as detail plans of the buildings will be available for the students.

Informatics

252-0839-00L

**W** 2 credits 2G L. E. Fässler, M. Dahinden

*Abstract*
Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists and tables and with relational databases, introduction to programming.

*Objective*
The students learn to
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

*Content*
1. Modeling and simulations
2. Data management with lists and tables
3. Data management with a relational database
4. Introduction to programming with Python

*Lecture notes*
All materials for the lecture are available at www.evim.ethz.ch

*Prerequisites / notice*
This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

Project Management for Construction Projects

101-0007-00L

**W** 4 credits 3S J. J. Hoffman

*Abstract*
This course is designed to lay down the foundation of the different concepts, techniques, and tools for successful project management of construction projects.
Objective

The goal is that at the end of this course students should have a good understanding of the different project management knowledge areas, the phases required for successful project management, and the role of a project manager. To demonstrate this, students will work in groups in different case studies to apply the concepts, tools and techniques presented in the class.

Content

Two 3 to 4 hours sessions towards the end of the lecture series will introduce a practical project to allow the teams to demonstrate the tools and techniques learned during the semester. The course will have a final quiz that will be graded.

The main content of the course is summarized in the following topics:
- Project and organization structures
- Project scheduling
- Resource management
- Project estimating
- Project financing
- Risk management
- Project Reporting
- Interpersonal skills

Lecture notes

The slides for the class will be available for download from Moodle at least one day before each class. Copies of all necessary documents will be distributed at appropriate times.

Literature

Relevant readings will be recommended throughout the course (and made available to the students via Moodle).

851-0589-00L Technology and Innovation for Development W 3 credits 2V P. Aerni

Abstract

Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

Objective

- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content

Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies.

The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes

Reader with issue-specific articles. E-version is partly available on Moodle


Aerni, P. (2021b) ‘Decentralized economic ecosystems in Switzerland and their contribution to inclusive and sustainable change’. Sustainability 13(8), 4181


Aerni, P. 2016a. Coping with Migration-Induced Urban Growth: Addressing the Blind Spot of UN Habitat. Sustainability 8(800)


Romer, P. 2020. What It Takes To Be a Leader in Both Basic Science and Technological Progress. Statement for House Budget Committee Hearing on Federal R&D (https://paulromer.net/statement-for-house-budget-committee/)


Prerequisites / notice

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester. The class will be taught in English. Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>W</th>
<th>Credits</th>
<th>G</th>
<th>Instructor(s)</th>
</tr>
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<tr>
<td>376-1177-00L</td>
<td>Human Factors I</td>
<td></td>
<td>3</td>
<td>2</td>
<td>M. Menozzi Jäckli, R. Huang, M. Siegrist</td>
</tr>
<tr>
<td>103-0569-00L</td>
<td>European Aspects of Spatial Development</td>
<td></td>
<td>3</td>
<td>2</td>
<td>A. Peric Momcilovic</td>
</tr>
</tbody>
</table>

Abstract

Human Factors I
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people’s health, well-being, and satisfaction as well as the overall system performance.

Objective

The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content

- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature

- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouchures, checklists, key articles etc. are uploaded in ILIAS

European Aspects of Spatial Development

Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Abstract

Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Objective

Keeping the general aim of exploring the European dimension of spatial planning in mind, the specific course learning objectives are as follows:
- to interpret the history of spatial planning at the transnational scale
- to understand and explain the content of the European spatial policy agenda
- to describe and analyse the role of territorial cooperation in making European spatial development patterns and planning procedures
- to discuss the changing role of planners and evaluate the ways of their engagement in European spatial policy-making

Content

- European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programmes on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

Lecture notes

The documents for the lecture will be provided at the moodle.
Literature

Obligatory literature:

Recommended literature:


Planning models:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

Planning systems in Europe:

Prerequisites / notice

Only for master students, otherwise a special permission by the lecturer is required.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td>Decision-making</td>
<td>assessed</td>
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<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</tbody>
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851-0252-08L Evidence-Based Design: Methods and Tools for Evaluating Architectural Design

Number of participants limited to 40

W 3 credits 2S 851-0252-08L M. Gath Morad, C. Hölscher, L. Narvaez Zertuche, C. Veddelier

252-0834-00L Information Systems for Engineers

W 4 credits 2V+1U 252-0834-00L G. Fourny

Abstract

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this course first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

Prerequisites / notice

- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
How can students of architecture become active agents of change? What does it take to go beyond a building's scale, making design.

**Creative Thinking**

assessed

**Engineering Design Optimization**

T. Stankovic, D. Griego, R. Rust

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowldege into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:

- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

**Engineering Design Optimization**

W 4 credits 4G K. Shea, T. Stankovic

Number of participants limited to 60.

**Scientific Machine and Deep Learning for Design and Construction in Civil Engineering**

W 3 credits 4G M. A. Kraus, D. Griego, R. Rust

This course will present methods of scientific machine and deep learning (ML / DL) for applications in design and construction in civil engineering. After providing proper background on ML and the scientific ML (SciML) track, several applications of SciML together with their computational implementation during the design and construction process of the built environment are examined.
The course will include theory and algorithms for SciML, programming assignments, as well as a final project assessment.

The topics to be covered are:
1. Fundamentals of Machine and Deep Learning (ML / DL)
2. Incorporation of Domain Knowledge into ML and DL
3. ML training, validation and testing pipelines for academic and research projects

A comprehensive series of computer/lab exercises and in-class demonstrations will take place, providing a “hands-on” feel for the course topics.

The course script is composed by lecture slides, which are available online and will be continuously updated throughout the duration of the course.

Fostered competencies
- Subject-specific Competencies
  - Concepts and Theories: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Problem-solving: not assessed
- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: not assessed
- Personal Competencies
  - Critical Thinking: not assessed
  - Self-awareness and Self-reflection: not assessed

Subject: Implementation of Environmental and Other Sustainability Goals

Objective
- Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0327-01 Advanced Environmental Assessments (2KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

Content
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
  - The concept of ‘Continuous Improvement’
  - Life Cycle Costing, Life Cycle Management
  - environmental performance measurement of an organisation, including ‘organisational LCA’ (Ecobalance), based on practical examples of companies and new concepts
  - single score env. assessment methods (Swiss ecopoints)
  - stakeholder management and sustainability oriented communication
  - an intro into sustainability issues of supply chain management
- Students will get small exercises related to course issues.

Prerequisites / notice
- Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic course, but the combined course, specifically offered and mandatory for their module).
- Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic will profit more from this course after reading an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5,2)).
Computational Methods of Energy- and Climate Design

As of FS23, this course will be offered in spring semesters only.

Objective - Domain-specific knowledge: Students have immersed knowledge about a certain complex, societal topic which will be selected every year. They understand the complex system context of the current topic, by comprehending its scientific, technical, political, social, ecological and economic perspectives.

- Analytical skills: The ETH Week participants are able to structure complex problems systematically using selected methods. They are able to acquire further knowledge and critically analyse the knowledge in interdisciplinary groups and with experts and the help of team tutors.

- Design skills: The students are able to use their knowledge and skills to develop concrete approaches for problem-solving and decision making to a selected problem statement, critically reflect on these approaches, assess their feasibility, to transfer them into a concrete form (physical model, prototypes, strategy paper, etc.) and to present this work in a creative way (role-plays, videos, exhibitions, etc.).

- Self-competence: The students are able to plan their work effectively, efficiently and autonomously. By considering approaches from different disciplines they are able to make a judgment and form a personal opinion. In exchange with non-academic partners from business, politics, administration, non-governmental organisations and media they are able to communicate appropriately, present their results professionally and creatively and convince a critical audience.

- Social competence: The students are able to work in multidisciplinary teams, i.e. they can reflect critically on their own discipline, debate with students from other disciplines and experts in a critical-constructive and respectful way and can relate their own positions to different intellectual approaches. They can assess how far they are able to actively make a contribution to society by using their personal and professional talents and skills as "Change Agents".

Content - Remote collaboration competence: The students work in a hybrid setting blending physical and virtual communication and collaboration methods and tools. They experience the potential and limitations of remote collaboration.

The seminar week is obligatory for students of all semesters. There are many and varied study contents.

The seminar week is obligatory for students of all semesters. There are many and varied study contents.

While deepening their knowledge about sustainable urban development, students will be introduced to various methods and tools for generating creative ideas and understanding how different people are affected by each part of the system. In addition to lectures and literature, students will acquire knowledge via excursions into the real world, empirical observations, and conversations with researchers and experts.

A key attribute of ETH Week is that students are expected to find their own problems, rather than just solve the problem that has been handed to them.

Therefore, the first three days of the week will concentrate on identifying a problem the individual teams will work on, while the last two days are focused on generating solutions and communicating the team’s ideas.

No prerequisites. Programme is open to Bachelor and Masters from all ETH Departments. All students must apply through a competitive application process at www.ethz.ch/ethweek. Participation is subject to successful selection through this competitive process.

Objective - Analytical Competencies - assessed

- Media and Digital Technologies - assessed
- Problem-solving - assessed

Social Competencies - Communication - assessed
- Cooperation and Teamwork - assessed
- Sensitivity to Diversity - assessed
- Negotiation - assessed

Personal Competencies - Adaptability and Flexibility - assessed
- Creative Thinking - assessed
- Critical Thinking - assessed
- Self-direction and Self-management - assessed

Prerequisites / notice

<table>
<thead>
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<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Semester</th>
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<tr>
<td>051-0911-22L</td>
<td>Seminar Week Autumn Semester 2022</td>
<td>2</td>
<td>3A</td>
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<tr>
<td>052-0639-22L</td>
<td>Climate Responsive Architecture with Hive</td>
<td>1</td>
<td>2G</td>
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<tr>
<td>063-0607-22L</td>
<td>Computational Methods of Energy- and Climate Design</td>
<td>3</td>
<td>2V</td>
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</table>

Abstract

The seminar week is obligatory for students of all semesters. There are many and varied study contents.

The students will be enabled to discuss narrowly formulated factual questions in small groups and in direct contact with the professors.

Content

- Recall general principles of climate responsive design and examples of it.
- Utilize 3D building geometries to conduct simplified energy demand and supply simulations.
- Observe relevant physical principles and interactions between climate, energy and geometry.
- Implement passive and active concepts for Climate Responsive Design.
- Apply Hive for building design analysis and integrate it into own designs or in design courses.
- Identify and harness synergies and trade-offs between climate, energy and architectural design aspects.

The course can be frequented individually, or as a prerequisite for other courses such as the master course Climate and Energy Systems 3 or architectural design studios.

Modules:

1. Course overview.
2. Introduction to climate responsive design.
3. Introduction to Rhino, Grasshopper and Hive.
4. Early solar analyses.
7. Real-world Applications and Examples.

This is a blended-learning self-paced ONLINE COURSE that can be started at any time.

A working Rhino 6 or 7 license is necessary.
Abstract
The course ‘Energy- and Climate Systems III’ introduces computational design and analysis methods and tools for climate responsive architectural design. Exercises throughout the semester allow applying new concepts learnt in exemplary architectural design tasks.

Objective
By the end of this course, students will be able to:

- compare and assess passive and active design strategies for bioclimatic buildings
- analyze environmental site characteristics for its climate and (solar) energy potentials
- apply computational simulation tools to support performance-driven designs
- translate design ideas into parametric models and into optimization problems
- synthesize learnt content of the course in exemplary architectural design tasks, serving as a basis for the students’ future design studios and projects

Content
1. Concepts of climate responsive design
   2. Computational analysis methods
      - Climate and site analysis
      - Daylight, airflow and energy simulations
      - Energy supply systems optimization models (energy hub)
   3. Computational methods for performance driven design
      - Parametric design
      - Sensitivity and uncertainty analysis
      - Single and multi-objective optimization
   4. Exercises and walkthroughs
   5. Invited expert speakers and panel discussion

Prerequisites / notice
ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h: Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

We will offer weekly 1h tutorial / practice sessions in the HIB open space to recap necessary background knowledge (simple statistics, Rhino & Gh modelling), as well as to practice tools and methods learnt in class. Dates to be announced later.

Requirements and Recommendations:
MSc Arch:
- Successfully completed the online blended learning course ‘Climate responsive architecture with Hive’ beforehand (Requirement)
- Successful participation in the course ‘Energie- und Klimasysteme I + II’ (Recommendation)

MSc MIBS / Eng:
- Successfully completed the online blended learning course ‘Climate responsive architecture with Hive’ beforehand. (Recommendation)
- Successful participation in the course ‘Building Systems’. (Recommendation)

All students need to be capable of working with ‘Rhinoceros 3D’ & ‘Grashopper’ on ‘Windows’ or willing to acquire the necessary skills before or during the course.

063-0611-22L The Digital in Architecture II
Prerequisite: Successful completion of the course
“Structural Design VI” (063-0606-00L), “Design III” (052-0541/43/45) or “Das Digitale in der Architektur” (063-0610-00L).

W 2 credits 1V+2U F. Gramazio, J. Medina Ibañez, M. Kohler

Abstract
Subject of the course is robotic fabrication in architecture. Through exercises, basic skills such as robotic control are being taught and applied to a small design and fabrication project. The course teaches how to develop a simple fabrication and material aware digital design process linked to a robotic fabrication procedure.

Objective
Students learn to use industrial robots such as the Universal Robot UR5 and understand basic principles of robotic control. At the end of the course, students are able to translate simple design ideas into robotic fabrication processes, which they can run independently. Furthermore students deepen their skills in Python and Grasshopper.

Prerequisites / notice
ITA Pool - information event on the courses offered at the institute ITA: Wednesday 7th September 2022, 10-11 h:
Room: HIB Open Space 2 (HIB E52) or online. Zoom link: https://ethz.zoom.us/j/6684810727

063-0805-22L History and Theory in Architecture IX

W 1 credit 1V T. Avermaete, H. Teerds

Abstract
This course offers a brief introduction to contemporary urban problems and challenges. Based on a thematic approach, the course explores how these issues pose a challenge to the fields of architecture, urban design and planning.

Objective
This course aims to offer a survey of the history and current state of urban theory for students of urban design and architecture.
It is a somewhat commonplace to say that we live in an ‘urban age’: cities are the most common habitat for the inhabitants of the world, today. Moreover, while more than half the global population lives in cities according to the reports of the UN, it is expected that within the next few decades this amount will increase to two-thirds. This ‘urban’ condition, however, cannot be generalized. Within the term ‘city’ a broad range of different urban conditions are taken together: from metropolises to suburban neighborhoods, and from shrinking (old industrial) cities to the new cities that prosper under the conditions of globalization. It also generalizes too much with regard to the urban condition within cities in the so-called Global North as compared to the Global South. In other words: the urban condition is as diverse as there are cities. However, it is also true that it is precisely in the cities that the challenges of our time are most apparent: globalization, gentrification, poverty, climate change. These topics call for a response.

The development of cities forms the topic of discussion, not only within the fields of architecture, urban design, spatial planning, but also among politicians, economists, anthropologists, philosophers, citizens and activists. The urban realm and reality has provoked them to think and write about its form and functioning, appearance and structure, to protest against particular issues, and to take initiatives to direct the development in a different direction. Designers and planners reflect on the urban developments as well, sometimes in participating in the development themselves, sometimes from the sideline.

This is obviously not new, nor limited to the current urban condition. The discourse regarding the size and growth of cities, its functioning and politics, has a long pedigree in history, going back to the establishment of Greek and Roman city-states. This survey course aims to offer an introduction to issues at stake in cities, tailored to students of architecture and urban design. It will explore the past and current discourses, and will access a broad range of perspectives. It also does an effort to expand the scope beyond regular Western-European and North-American perspectives from Western world. The course will specifically address how architecture (positively or negatively) is involved in these issues.

The aim of the course is to challenge the question how architects and urban designers can have an influence on urban developments and issues that we often regard as beyond the scope of architecture. With this challenge, also students are urged to reflect upon their own position regarding architectural interventions in the urban fabric, facing the current condition of the urban environment (in all its diversity).

This course consists of weekly, one-hour lectures that address one particular topic at a time. In each lecture, this theme is investigated through different texts and case-studies that highlight crucial moments in the history and developments of cities. At the same time, the case studies will be structured so as to bridge between urban theories and concrete urban situations, design reflections and political ambitions. This will help convey to students the historical pedigree of current discourses on cities, whether simultaneously gain insight the role of designers in respect to the chosen topic. Students will prepare the meetings by reading fragments from core texts on the forehand.

The course is finalized through the writing of an essay, wherein the student is challenged to question how architectural agency can address (a) contemporary urban issue(s).

Lecture 01 – Introduction
Lecture 02 – Politics
Lecture 03 – Public Space
Lecture 04 – Capital
Lecture 05 – Climate Change
Lecture 06 – Technology
Lecture 07 – Tourism
Lecture 08 – Migration
Lecture 09 – Housing
Lecture 10 – Participation
Lecture 11 – Architectural Agency

For this course, each week students will read fragments from key readings on the topics addressed. The readings will be made available via the website of the course prior to HS2022.

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<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
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<th>Social Competencies</th>
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<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
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<td>Self-presentation and Social Influence</td>
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**052-0731-22L Housing Issues and Challenges in the Global South**

**Contributions of Architecture**

Can architecture, urban design and planning contribute to make housing and cities more equitable and inclusive? Answers to this question will be provided by socially engaged architects from Europe, Asia and Latin America through the presentation of concrete actions and projects.

**Abstract**

After a general introduction to the causes and consequences of the current global housing and urbanisation challenges, the students will learn through concrete examples that architects, planners and urban designers can make a difference. Socially engaged architects, designers and planners from Europe, Asia and Latin America will present actions and projects that contributed to make human settlements more inclusive, liveable and sustainable.
The course will focus on the following topics:
- Global housing and urban challenges: an introduction
- From planning to actions against the commodification of public spaces in Vienna
- Countering the financialization of the city of Berlin
- Un-gating the city: the case of Bogota, Colombia
- Creating public space for popular culture in Barranquilla, Colombia
- Designing lights and sites of publicness in Mali
- Architects’ role in ensuring informal settlers’ right to the city in Bolivia
- Architectural activism and the re-emergence of housing cooperatives in Spain
- Enhancing social inclusion through participatory urban design in Milano, Italy
- Urban environmental activism, architecture and housing cooperatives in Switzerland
- Learning from vernacular building practices in India and Latin America
- Rebuilding housing and communities after conflicts and disasters
- Architecture for reconciliation and peace building in post-conflict settings

A bibliography will be made available to inscribed students prior to the start of the semester.

**Introduction to Modeling and Optimization of Sustainable Energy Systems**

**Abstract**
This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

**Objective**
At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course “Introduction to Modeling and Optimization of Sustainable Energy Systems”, the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

**Climate Policy**

**Abstract**
This course provides an in-depth analysis of both the theoretical underpinnings to different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.

Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

This course is about all that. The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

**Literature**
There will be daily reading assignments, which will then discuss critically during the class sessions. All of these will be posted in PDF format on a course Moodle. In addition, there will be two books to be read over the course of the semester. Both of these can be accessed from the ETH library or in PDF form free of charge. They are:

The course is designed to expose students to different ways of thinking across multiple disciplines, but with a focus on how, as future professionals, they can facilitate and provide tangible solutions that are multi-functional and accepted by a wide array of decision-makers. Selected topics include: (1) understanding how Nature-based solutions and Blue Green Infrastructure can be used to address global societal challenges, (2) understanding the need for different levels of planning in order to design effective solutions and policies that will ensure sustainable development, (3) identifying and understanding the function of suitable infrastructure to complement existing systems, (4) support tools and quantitative approaches for evidence-based performance evaluation, and (5) planning and decision-making around Nature-based solutions.

Content

The course will provide students with an overarching picture of how Nature-based solutions and Blue Green infrastructure are being used to make societies and cities greener, more resilient, climate-adaptive, more liveable, sustainable, and especially, how water resources management is being leveraged to accomplish this. Students will gain insight into suitable tools and approaches to navigating interactions between relevant stakeholders, hands-on experience through a scenario-based real-world project, a field visit to an urban case study, as well as insights from leading public and private sector experts in Nature-based Solutions and Blue Green Infrastructure.

Lecture notes

There is no textbook. Learning materials consist of lectures, videos, and references provided by the instructors on the course Moodle page.

Prerequisites / notice

Bachelor or Master studies in environmental engineering, environmental sciences, or architecture/urban planning.

For further information, contact the MAS coordinator, Darcy Molnar (darcy.molnar@eth-baug.ethz.ch)

★ Project Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>066-0425-00L</td>
<td>Integrated Design MiBS</td>
<td>O</td>
<td>6</td>
<td>3V+3U</td>
<td>A. Schlüter</td>
</tr>
<tr>
<td>Abstract</td>
<td>During the integrated design studio students work on a selected integrated architectural / urban design project, considering both energy- and climate systems (HVAC) as well architectural and urban design in a specific site context. The objective is to follow an integrated design process to achieve synergistic solutions.</td>
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<tr>
<td>Objective</td>
<td>The integrated design studio enables students to identify site specific energy demand and potentials, develop integrated energy and climate systems on both the urban and building scale and evaluate their interactions and impact on building design and operation.</td>
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<tr>
<td>Content</td>
<td>Retrieving relevant concepts and technologies of energy and HVAC systems, students are able to develop and compare integrated concepts using appropriate methods and digital toolsets and present them to a mixed audience using drawings, renderings and reports.</td>
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<tr>
<td>Lecture notes</td>
<td>Skripts are specific to the design task and distributed at the beginning of the course.</td>
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<tr>
<td>Literature</td>
<td>A literature list will be distributed at the beginning of the course.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Students must have successfully passed the first year of MiBS studies.</td>
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★ Semester Project

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>066-0431-00L</td>
<td>Semester Project MiBS</td>
<td>O</td>
<td>6</td>
<td>13A</td>
<td>Supervisors</td>
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<tr>
<td>Abstract</td>
<td>The semester project can commence only after the first year of course work is completed.</td>
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<tr>
<td>Objective</td>
<td>The semester project focuses in solving specific research questions in the field of integrated building systems. The goal is to apply acquired knowledge which is gained throughout the first year of the master's program. The semester project is advised by a professor who is affiliated with one of the partner departments of the Master program &quot;Integrated building systems&quot;.</td>
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<tr>
<td>Content</td>
<td>The semester project is designed to train students in solving specific research questions in the field of integrated building systems. The goal is to apply acquired knowledge which is gained throughout the first year of the master's program. The semester project is advised by a professor who is affiliated with one of the partner departments of the Master program &quot;Integrated building systems&quot;.</td>
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★ Science in Perspective

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<th>Lecturers</th>
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<tbody>
<tr>
<td>052-0801-00L</td>
<td>Global History of Urban Design I</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>T. Avermaete</td>
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<tr>
<td>Abstract</td>
<td>This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.</td>
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### Objective
The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.

### Content
In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01. The History and Theory of the City as Project
02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03. The Idea of the Polis: Rome, Greece and Beyond
04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
09: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
10: Civilization Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
11: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

### Literature
There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

### Prerequisites / notice
Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

<table>
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<tr>
<th>Course Code</th>
<th>Title</th>
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<tr>
<td>851-0609-06L</td>
<td>Governing the Energy Transition</td>
<td>2</td>
<td>W</td>
<td>T. Schmidt</td>
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<tr>
<td>351-0555-00L</td>
<td>Open- and User Innovation</td>
<td>3</td>
<td>W</td>
<td>S. Häfliger, S. Spaeth</td>
</tr>
<tr>
<td>860-0023-00L</td>
<td>International Environmental Politics</td>
<td>3</td>
<td>W</td>
<td>T. Bernauer</td>
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### Lecture notes
Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

### Literature
A reading list will be provided via moodle.ethz.ch at the beginning of the semester.

### Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

### Performance assessment
Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active iass participation is required.

### Content
This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active iass participation is required.

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The slides of the lectures are made available slides of the continuously through the SMI website:

- Relevant literature for the course includes slides and reading assignments. Papers will be made available through a corresponding Moodle group.
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

851-0101-74L Sustainable Development - Bridging Art and Science W 3 credits 2G S. Patel, J. Neve

Abstract
In this course students deepen their knowledge about global development and sustainability issues. We will show five movies each of them linked to one of the five F’s (Planet, People, Prosperity, Peace and Partnerships) reflecting the topics of the 2030 Agenda. Afterwards the movie will be critically discussed with researchers and relevant stakeholders from the broader society.

Objective
• Students get a broad understanding of some of the most important issues and discussions related to sustainable development.
• Students get exposed to diverse realities of young people in developing countries
• Students can critically reflect upon the information that is presented to them in the movies and relate it to the broader discussions around sustainable development.
• Students reflect on issues concerning communicating research and the realities of low-income settings to a wider public.

Content
The aim of the course is to deepen student’s knowledge about global issues and to inspire them to reflect critically upon complex topics, which are related to the broader discourse on sustainable development. In each class, we show a documentary film, which is linked to one of the five critical areas of the 2030 Agenda (Planet, People, Prosperity, Peace and Partnerships), putting specific focus on realities in developing countries. Following the movie screenings, we will discuss the topic of the film in the light of sustainable development with an expert from academia and/or a practitioner from the field of development cooperation. In preparation for each class, the students read an academic paper, which will also be considered in the discussion. The idea of “Bridging Art and Science” is to expose an interdisciplinary group of students to artistic and scientific perspectives alike and to challenge them to deal with bias and polarization, and the role that the media and films play in that regard. The participants of the course will be given the chance to embrace the complexity of sustainable global development.

851-0252-01L Human-Computer Interaction: Cognition and Usability W 3 credits 2S H. Zhao, S. Credé, C. Hölscher

Number of participants limited to 35.

Abstract
This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.

Objective
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

363-0311-00L Psychological Aspects of Risk Management and Technology W 3 credits 2V G. Grote, N. Bienefeld-Seall, R. Schneider, M. Zumbühl

Number of participants limited to 65.

Abstract
Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are treated. Three components of risk management (risk identification/evaluation, risk mitigation, risk communication) and underlying psychological and organizational processes are discussed, using company case studies to promote in-depth understanding.
- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organisations
- Know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  o Risk identification and evaluation
  o Risk mitigation
  o Risk communication

- Psychological and organizational concepts relevant in risk management
  o Decision-making under uncertainty
  o Risk perception
  o Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Group projects related to company case studies
- There is no script, but slides will be made available before the lectures.
- There are texts for each of the course topics made available before the lectures.

The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

**851-0742-00L**

**Contract Design I**

This course is taught by Professor Alexander Stremitzer ([https://laweconbusiness.ethz.ch/group/professor/stremitzer.html](https://laweconbusiness.ethz.ch/group/professor/stremitzer.html)). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

### Objective

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:

1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.
Network science is a distinct domain of data science that is characterized by a specific kind of data being studied.

Concepts and Theories

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

Analytical Competencies

Students will be able to identify and categorize research problems with respect to substantive theory:

- Empirical Research and Network Data
- Macro and Micro Structure
- Centrality
- Roles
- Cohesion

Lecture notes

Lecture notes are distributed via the associated course moodle.

Literature

Further literature will be recommended in the lectures.

851-0252-15L Network Analysis

Particularly suitable for students of D-INFK, D-MATH

W 3 credits 2V U. Brandes

Abstract

Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Objective

Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

Content

The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

- Empirical Research and Network Data
- Macro and Micro Structure
- Centrality
- Roles
- Cohesion

851-0101-86L Complex Social Systems: Modeling Agents, Learning, and Games

Number of participants limited to 100.

Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract

This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Content

Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lecture notes

The lecture slides will be presented on the course web page after each lecture.

Literature

Agent-Based Modeling

https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization


Traffic and related self-driven many-particle systems

Reviews of Modern Physics 73, 1067

https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)

https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics

https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)

https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.
Prerequisites / notice

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Number of participants limited to 40.

Abstract

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

Objective

To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

Content

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.

From Traffic Modeling to Smart Cities and Digital Democracies

W 3 credits 2S D. Helbing, S. Mahajan

851-0467-00L

Autumn Semester 2022
Literature

Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future

Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/2020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/686.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective-collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f488e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_1_fkmr1_1?dchild=1&keywords=coordination+Jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Decentralized Collective Learning for Self-managed Sharing Economies
https://dl.acm.org/doi/abs/10.1145/3277688

Further literature will be recommended in the lectures.

Prerequisites / notice

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Leadership and Responsibility: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: assessed

Master’s Thesis

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
066-0434-00L | Master’s Thesis | O | 30 credits | 40D | Professors

Abstract
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking.

Objective
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking.

Content
A 6-months Master thesis completes the Master's program of Integrated Building Systems. With the thesis project students are expected to demonstrate their ability to independent and structured scientific thinking. The thesis can be performed either at ETH Zurich, an industrial enterprise, or in a research institution, but has to be advised by one or more professors affiliated with the Master program “Integrated building systems”.

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
101-0414-AAL | Transport Planning | E- | 3 credits | 6R | K. W. Axhausen

Abstract
The lecture course discusses the basic concepts, approaches and methods of transport planning in both their theoretical and practical contexts.

Objective
The course introduces the basic theories and methods of transport planning.

Content
Basic theoretical links between transport, space and economic development; basic terminology; measurement and observation of travel behaviour; methods of the four stage approach; cost-benefit analysis.

Literature

Integrated Building Systems Master - Key for Type

<table>
<thead>
<tr>
<th></th>
<th>Compulsory</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>E-</td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>
### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

**European Credit Transfer and Accumulation System**

- Special students and auditors need special permission from the lecturers.
# Interdisciplinary Sciences Bachelor

## Physical-Chemical Direction

### 1. Semester (Physical-Chemical Direction)

#### Compulsory Subjects First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10 credits</td>
<td>6V+3U</td>
<td>G. Felder</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.

**Objective**

The ability to work with the basics of calculus in a mathematically rigorous way.

**Literature**

- K. Königsberger: Analysis 1 [Link](https://link.springer.com/book/10.1007/978-3-642-18490-1)
- V. Zorich: Mathematical Analysis I (englisch) [Link](https://link.springer.com/book/10.1007/978-3-662-48792-1)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>P. Biran, M. Einsiedler</td>
</tr>
</tbody>
</table>

**Abstract**


**Objective**

- Mastering basic concepts of Linear Algebra
- Introduction to mathematical methods

**Content**

- Basics
- Vector spaces and linear maps
- Systems of linear equations and matrices
- Determinants
- Endomorphisms and eigenvalues

**Literature**

Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester.


In addition we recommend this general introduction into studying mathematics:


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-1701-00L</td>
<td>Physics I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>W. Wegscheider</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives a first introduction to Physics with an emphasis on classical mechanics.

**Objective**

Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0011-01L</td>
<td>General Chemistry (Physical Chemistry) I</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>H. J. Wörner</td>
</tr>
</tbody>
</table>

**Abstract**

The lecture provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.
Objective

After the lecture, students will be able to,
- to calculate physical quantities and their units which are important for chemistry,
- name some properties of chemically relevant particles and propose experimental methods to determine these properties,
- name applications and hazards of radioactivity,
- categorize radioactive decay processes and mathematically represent the time course of simple decay reactions and qualitatively predict and represent them,
- describe wave and particle properties of electromagnetic radiation and matter and propose experimental methods for their detection,
- to explain the basics of quantum mechanics (meaning of the wave function, Heisenberg's uncertainty principle, operators, commutators) and to perform simple calculations with them,
- analyze and calculate absorption and emission spectra of single-electron atoms,
- to set up the Schrödinger equation for a molecular multi-particle system,
- independently solve the Schrödinger equation for the model systems of particles in a box and harmonic oscillator in one dimension and generalize to higher dimensional non-interacting problems,
- model molecular vibrations of diatomic molecules using the harmonic and anharmonic oscillator model,
- explain the concept of an orbital and represent mathematically and pictorially the qualitative form of the orbitals of the hydrogen atom,
- explain the structure of the periodic table of elements with the help of the orbital concept,
- recognize and use similarities in the electronic structure of atoms to predict chemically relevant properties, and
- establish term symbols for atomic ground states.

Content

Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions. Atomic orbitals and energy levels: ionization energies, atomic spectroscopy, term values and symbols. Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements. Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

Lecture notes

See homepage of the lecture.

Literature

See homepage of the lecture.

Prerequisites / notice

Voraussetzungen: Maturastoff. Insbesondere Integral- und Differenialrechnung.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

assessed

Additional First Year Compulsory Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-0011-04L</td>
<td>Practical Course General Chemistry</td>
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<td></td>
<td>Latest online enrolment is 19.09.2022</td>
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</tbody>
</table>

Information about the practical course will be given on the first day.

Abstract

Qualitative analysis (determination of cations and anions), acid-base-equilibria (pH-values, titrations, buffer), precipitation equilibria (gravimetry, potentiometry, conductivity), redox reactions (syntheses, redox-titrations, galvanic elements), metal complexes (syntheses, complexometric titration).

Analysis of measured data, vapour pressure, conductivity, calorimetry, solubility.

Objective

Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation state and redox behaviour (syntheses), redox-titrations, galvanic elements, metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration).

Analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimetry, solubility).

Content

The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their states of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes

http://www.gruetzmacher.ethz.ch/education/labcourses


Moodle Lernplattform

Literature

Compulsory: online enrolment latest one week after start of the semester.

Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html

Electives

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>529-0011-02L</td>
<td>General Chemistry (Inorganic Chemistry I)</td>
<td>W+</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>A. Togni</td>
</tr>
</tbody>
</table>

Abstract

Introduction to the chemistry of ionic equilibria: Acids and bases, redox reactions, formation of coordination complexes and precipitation reactions.

Objective

Understanding and describing ionic equilibria from both a qualitative and a quantitative perspective.

Content

Chemical equilibrium and equilibrium constants, mono- and polyprotic acids and bases in aqueous solution, calculation of equilibrium constants.

Lecture notes

Copies of the course slides as well as other documents will be provided as pdf files via the moodle platform.

Literature


529-0011-03L | General Chemistry (Organic Chemistry I) | W+  | 3 credits | 2V+1U | P. Chen               |

Abstract

Introduction to Organic Chemistry. Classical structure theory, stereochemistry, chemical bonds and bonding, symmetry, nomenclature, organic thermochemistry, conformational analysis, basics of chemical reactions.

Objective

Introduction to the structures of organic compounds as well as the structural and energetic basis of organic chemistry.

Content


Lecture notes

Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung gestellt

Data: 01.11.2022 12:41

Autumn Semester 2022
3. Semester (Physical-Chemical Direction)

Examination Block

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0422-00L</td>
<td>Physical Chemistry II: Chemical Reaction Kinetics</td>
<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>R. Signorell</td>
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<tr>
<td>Objective</td>
<td>Introduction to Chemical Reaction Kinetics</td>
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<tr>
<td>Lecture notes</td>
<td>Will be provided</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Voraussetzungen:</td>
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<tr>
<td></td>
<td>- Mathematik I und II</td>
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<tr>
<td></td>
<td>- Allgemeine Chemie I und II</td>
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<tr>
<td></td>
<td>- Physikalische Chemie I</td>
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<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>Y. Chu</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introductory course on quantum and atomic physics including optics and statistical physics.</td>
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<tr>
<td>Objective</td>
<td>A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.</td>
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<tr>
<td>Content</td>
<td>Einführung in die Quantenphysik: Planck'sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrscbe Atommodell, de-Broglie Materiewellen.</td>
<td></td>
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<tr>
<td>Literature</td>
<td>- M. Alonso, E. J. Finn</td>
<td></td>
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</tbody>
</table>

Electives

The Bachelor’s programme in Interdisciplinary Sciences allows students to choose from any subject taught at a Bachelor level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the 2nd year. See the Programme Regulations 2018 for further details.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>252-0847-00L</td>
<td>Computer Science</td>
<td>W</td>
<td>5</td>
<td>2V+2U</td>
<td>C. Cotrini Jimenez, F. O. Friedrich Wicker</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<tr>
<td></td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.</td>
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<td>Content</td>
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<td>The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
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<td>Lecture notes</td>
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<td>English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.</td>
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<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
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<td></td>
<td>Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000</td>
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<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>E. Kowalski</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.</td>
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<td>Objective</td>
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<td></td>
<td>Working knowledge of functions of one complex variables; in particular applications of the residue theorem.</td>
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<td>Literature</td>
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<td></td>
<td>Th. Gamelin: Complex Analysis. Springer 2001</td>
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<td></td>
<td>D. Salamon: &quot;Funktionentheorie&quot;. Birkhauser, 2011. (In German)</td>
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<td></td>
<td>K.Jaenich: Funktionentheorie. Springer Verlag</td>
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<td></td>
<td>R.Remmert: Funktionentheorie I. Springer Verlag</td>
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<td></td>
<td>E.Hille: Analytic Function Theory. AMS Chelsea Publications</td>
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<tr>
<td>401-2333-00L</td>
<td>Mathematical Methods of Physics I</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>T. H. Willwacher</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>C. Anastasiou</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Objective</td>
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<td></td>
<td>Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.</td>
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<td>Content</td>
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<td>The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.</td>
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<td>Lecture notes</td>
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<td>Auf Moodle</td>
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<td></td>
<td>Literature</td>
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<td></td>
<td>G. Baym, Lectures on Quantum Mechanics</td>
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<td></td>
<td>E. Merzbacher, Quantum Mechanics</td>
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<td>L.I. Schiff, Quantum Mechanics</td>
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<tr>
<td></td>
<td>R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals</td>
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<td></td>
<td>J.J. Sakurai: Modern Quantum Mechanics</td>
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<td></td>
<td>A. Messiah: Quantum Mechanics I</td>
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<td></td>
<td>S. Weinberg: Lectures on Quantum Mechanics</td>
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</tbody>
</table>
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.

Objective

The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, thermal properties of insulators; metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism, superconductivity.

Lecture notes

The script will be available on moodle.

Literature

Ibach & Lüth, Festkörperphysik
C. Kittel, Festkörperphysik
W. Känzig, Kondensierte Materie

Prerequisites / notice

Voraussetzungen: Physik I, II, III wünschenswert

402-0263-00L

Astrophysics I

W
10 credits
3V+2U
S. Lilly

Abstract

This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.

Objective

The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.

Lecture notes

A comprehensive “script” (240 pages, with detailed derivations) is provided to students. In addition, all powerpoint slides shown in the lectures are provided.

402-0595-00L

Semiconductor Nanostructures

W
6 credits
2V+1U
T. Ihn

Abstract

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

Objective

At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:

1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Content

1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k.p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Lecture notes


In addition to the lecture notes, the following supplementary books can be recommended:


Prerequisites / notice

The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitious students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.
**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td><strong>Method-specific Competencies</strong></td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
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<tr>
<td><strong>Social Competencies</strong></td>
<td>Communication</td>
<td>not assessed</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
<td>assessed</td>
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<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<tr>
<td><strong>Personal Competencies</strong></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>

**402-2203-01L Classical Mechanics**

**Abstract**
A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

**Objective**
Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

**529-0051-00L Analytical Chemistry I**

**Abstract**
Introduction into the most important spectroscopical methods and their applications to gain structural information.

**Objective**
Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications.

**Content**
Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.
- UV/VIS spectroscopy: Basics, interpretation of electron spectra. Circular dichroism (CD) and optical rotation dispersion (ORD).

**Lecture notes**
Script will be for the production price.

**Literature**
- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

**Prerequisites / notice**
Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

**529-0121-00L Inorganic Chemistry I**

**Abstract**
Discussion of syntheses, structures, and general reactivity of coordination compounds of the transition metals as well as the lanthanides and actinides. Introduction of methods of characterization, physical-chemical properties of coordination compounds as well as principles of radiochemistry.

**Objective**
The students will learn and understand the methodological basics of binding theory in complexes of transition metals. They will be able to explain the structure, chemical bonding, spectroscopic properties as well as general strategies for the synthesis of complexes of transition metals. The students will acquire knowledge on the fundamentals of radioactive decay and radiochemistry. Furthermore, they will be familiar with the basics of inorganic chemistry of lanthanides and actinides.

**Content**
This course consists of the following parts, which introduce the students to the chemistry of transition metals as well as lanthanides and actinides: 1) General definitions and terms in coordination chemistry; 2) Coordination numbers and structures; 3) Ligand types; 4) The chemical bond in coordination compounds part A: Crystal field theory and ligand field theory; 5) The chemical bond in coordination compounds part B: Qualitative MO theory; 6) Reactivity and reaction mechanisms of coordination compounds; 7) Group theory and character tables; 8) Properties and parameterization of coordination compounds; 9) Introduction to radiochemistry; 10) Principles of the chemistry of the lanthanides and actinides.

**Literature**
The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.


529-0221-00L Organic Chemistry I W 3 credits 2V+1U H. Wennemers
Abstract This course will build upon the basic knowledge of structure and reactivity of organic molecules gained in AC/OCI and AC/OCII. The module aims to provide a wide understanding of the occurrence, synthesis, properties, and reactivity of carbonyl compounds.
Objective The course will include theoretical and practical aspects of organic chemistry, focusing on carbonyl compounds. Students will learn about the synthesis and reactivity of aldehydes and ketones, including their reactions with aqueous solutions, formation of acetals and imines, nucleophilic addition reactions, and other important reactions.
Lecture notes The lecture slides, problem sets, and additional documents are provided online. Link: https://wennemers.ethz.ch/education.html

701-0023-00L Atmosphere W 3 credits 2V E. Fischer, T. Peter
Abstract Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.
Objective The course covers the fundamental principles of atmospheric science, including the physical structure, chemical composition, trace gases, and atmospheric cycles. It also delves into the study of atmospheric circulation, stability, radiation, condensation, clouds, and the oxidation capacity of the atmosphere.
Content Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.
Lecture notes Written information will be supplied.
Literature

701-0461-00L Numerical Methods in Environmental Physics W 3 credits 2G C. Schär, C. Zeman
Abstract This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.
Objective The course focuses on the development and application of numerical methods for solving mathematical models in environmental science. Students will learn about numerical methods and their implementation using Python.
Content Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration schemes, non-linearly, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-section of Environmental Science.
Literature List of literature is provided.

701-0473-00L Weather Systems W 3 credits 2G M. A. Sprenger, F. Scholder-Aemisegger
Abstract Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes.
Objective The course focuses on the study of atmospheric circulation and weather systems. Students will learn about satellite observations, vertical soundings, geostrophic and thermal wind, and cyclones at mid-latitude.
Content Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water vapour transport in the atmosphere; water isotopes.
Lecture notes Lecture notes and slides
Literature Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1358 of 2416


701-0475-00L Atmospheric Physics  
**Abstract**
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.

**Objective**
- Students are able to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.
- They are able to evaluate the significance of clouds and aerosol particles for artificial weather modification.

**Content**
The course starts with introducing selected concepts of thermodynamics for atmospheric processes. The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to classify radiosondes with the help of the thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

**Lecture notes**
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15367

**Literature**

**Prerequisites / notice**
For certain capsers we’ll use the concept of “flipped classroom” (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.

Fostered competencies
- Subject-specific Competencies: Concepts and Theories, Analytical Competencies, Problem-solving, Communication, Critical Thinking, Self-direction and Self-management

701-0501-00L Pedosphere  
**Abstract**
Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

**Objective**
Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.

The course "Pedosphäre" teaches and examines the competences process understanding and systems understanding.

**Content**
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

**Lecture notes**

**Literature**
Prerequisites: Basic knowledge in chemistry, biology and geology.

**Prerequisites / notice**

Fostered competencies
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Problem-solving

752-4001-00L Microbiology  
**Abstract**
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylology and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

**Objective**
Teaching of basic knowledge in microbiology.

**Content**

**Lecture notes**
Wird von den jeweiligen Dozenten ausgegeben.

**Literature**
Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

>>> Laboratory Courses, Semester Papers, Proseminars, Field Trips

Further laboratory courses must be applied for at the respective Director of Studies.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>529-0011-04L</td>
<td>Practical Course General Chemistry</td>
<td>O</td>
<td>8</td>
<td>12P</td>
<td>H. V. Schönberg, E. C. Meister</td>
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</tbody>
</table>
Information about the practical course will be given on the first day.

Abstract
Qualitative analysis (determination of cations and anions), acid-base-equilibria (pH-values, titrations, buffer), precipitation equilibria (gravimetry, potentiometry, conductivity), redoxreactions (syntheses, redox-titrations, galvanic elements), metal complexes (syntheses, complexometric titration).

Analyses of measured data, vapour pressure, conductivity, calorimetry, solubility.

Objective
Qualitative analysis (simple cation and anion separation process, determination of cations and anions), acid-base-equilibria (strengths of acids and bases, pH- and pKa-values, titrations, buffer systems, Kjeldahl determination), precipitation equilibria (gravimetry, potentiometry, conductivity), oxidation state and redox behaviour (syntheses), redox-titrations, galvanic elements, metal complexes (syntheses of complexes, ligand exchange reactions, complexometric titration) analysis of measured values (measuring error, average value, error analysis), states of aggregation (vapour pressure), characteristics of electrolytes (conductivity measurements), thermodynamics (calorimetry, solubility).

Content
The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of quantitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their states of aggregation as well as changes of selected physical values will be recorded and discussed.

Lecture notes
http://www.gruetzmacher.ethz.ch/education/labcourses

Literature

Prerequisites / notice
Compulsory: online enrolment latest one week after start of the semester
Safety concept: https://chab.ethz.ch/studium/bachelor1.html

<table>
<thead>
<tr>
<th>529-0129-00L</th>
<th>Inorganic and Organic Chemistry II</th>
<th>W</th>
<th>11 credits</th>
<th>16P</th>
<th>V. Mougel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Introduction to the experimental methods of Inorganic Chemistry</td>
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<tr>
<td>Objective</td>
<td>The teaching laboratory offers an insight into different aspects of Inorganic Chemistry, including solid state chemistry, organometallic chemistry, kinetics, etc. The synthesis, characterization and analysis of inorganic compound are a major topic. Special emphasis on experimental techniques of synthetic inorganic chemistry, in particular the safe handling of reactive and pyrophoric chemical and solvent purification and drying techniques. Emphasis is given to scientific writing (experiment reports).</td>
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<tr>
<td>Content</td>
<td>Inorganic chemistry part: Synthesis and analysis of elemento-organic compounds, metal complexes, and organometallic compounds. Introduction to Schlenk techniques, solid state synthesis, and kinetics. Introduction in the chemistry library: literature data banks and collections of spectra. Organic synthesis with organometallic compounds and catalysts: Experiments in the framework of a selected specialised project. Possible projects: Rh catalysed asymmetric hydrogenation of enamides, Mn-catalysed epoxidation of olefins, Cu catalysed Diels-Alder reactions, synthesis of organo-boron compounds and Pd catalysed coupling with halides, Ru catalysed transfer hydrogenation.</td>
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<tr>
<td>Lecture notes</td>
<td>A manual is distributed in the teaching laboratory.</td>
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</tbody>
</table>
| Prerequisites / notice | - Passed Basisprüfung  
- Passed Practical Course General Chemistry (1. Semester, 529-0011-04)  
- Passed Practical Course Inorg. and Org. Chemistry I (2. Sem., 529-0230)  
- Continuous Attendance of Course Inorg. Chemistry 1 (3. Sem., 529-0121) and Analytical Chemistry 1 (3. Sem., 529-0051)  
If necessary, access priority will be settled according to the results of the first-year examinations. |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1360 of 2416
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that are operated within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochronological perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

The newly conceived lecture is supported by scripts.

<table>
<thead>
<tr>
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<th>Credits</th>
<th>Lecture Hours</th>
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<td>variable: the notion of a function, of the derivative, the</td>
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<td>derivative, the idea of a differential equation, complex</td>
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<td>G. B. Thomas, M. D. Weir, J. Hass: Analysis 1, Lehr- und</td>
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<td></td>
<td>Übungsbuch, Pearson-Verlag</td>
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<td>R. Sperb/M. Akveld: Analysis I (vdf)</td>
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<td>L. Papula: Mathematik für Ingenieure und Naturwissenschaftler</td>
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<td></td>
<td>(3 Bände), Vieweg further reading suggestions will be indicated</td>
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<td>Techniques and Technologies</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<td></td>
<td>and a quantitative perspective</td>
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<td>tic acids and bases in aqueous solution, calculation of equilibri</td>
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<td>electrode potentials, Nerst equation, coordination chemistry, step</td>
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<td>wise formation of metal complexes, solubility</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Copies of the course slides as well as other documents will be pr</td>
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<tr>
<td></td>
<td>ovided as pdf files via the moodle platform.</td>
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<td><strong>Literature</strong></td>
<td>C. E. Housecroft &amp; E. C. Constable: Chemistry, An Introduction to</td>
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<table>
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<th>General Chemistry (Organic Chemistry) I</th>
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<tbody>
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<td></td>
<td>stereochemistry, chemical bonds and bonding, symmetry, nomenclature,</td>
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<td></td>
<td>organic thermochemistry, conformational analysis, basics of chemical</td>
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<td></td>
<td>reactions.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Introduction to the structures of organic compounds as well as the</td>
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<td>structural and energetic basis of organic chemistry.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>nomenclature, learning of classical structures and stereochemistry:</td>
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<td>isomerism, Fischer projections, CIP rules, point groups, molecular</td>
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<td>symmetry and chirality, topicity, chemical bonding: Lewis bonding</td>
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<td>model and resonance theory in organic chemistry, description of</td>
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<td>linear and cyclic conjugated molecules, aromaticity, Huckel rules,</td>
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<td>intermolecular interactions.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Unterlagen werden als PDF über die ILIAS-Plattform zur Verfügung</td>
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<td>C. E. Housecroft &amp; E. C. Constable: Chemistry, An Introduction to</td>
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</table>
This document appears to be a course description for a general chemistry course, including details on course objectives, competencies, and course content. The course provides an introduction to some of the physical fundamentals of chemistry, in particular radioactivity, quantum mechanics, the structure of matter and an atom, the periodic table of elements, and chemical bonding.

### Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

### Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

### Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Content
- Atomic structure and structure of matter: atomic theory, elementary particles, atomic nuclei, radioactivity, nuclear reactions.
- Atomic orbitals and energy levels: ionisation energies, atomic spectroscopy, term values and symbols.
- Quantum mechanical atom model: wave-particle duality, the uncertainty principle, Schrödinger's equation, the hydrogen atom, construction of the periodic table of the elements.
- Chemical bonding: ionic bonding, covalent bonding, molecular orbitals.

### Lecture notes
See homepage of the lecture.

### Literature
See homepage of the lecture.

### Prerequisites / notice
Voraussetzungen: Maturastoff. Insbesondere Integral- und Differentirechnung.

### Fostered competencies
- Subject-specific Competencies
- Concepts and Theories

### Additional First Year Compulsory Subjects

<table>
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<tr>
<th>Number</th>
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<td>O</td>
<td>8</td>
<td>12P</td>
<td>H. V. Schönberg, E. C. Meister</td>
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</table>

The general aim for the students of the practical course in general chemistry is an introduction in the scientific work and to get familiar with simple experimental procedures in a chemical laboratory. In general, first experiences with the principal reaction behaviour of a variety of different substances will be made. The chemical characteristics of these will be elucidated by a series of qualitative experiments alongside with the corresponding qualitative analyses. In order to get an overview of classes of substances as well as some general phenomena in chemistry suitable experiments have been chosen. In the second part of the practical course, i.e. physical chemistry, the behaviour of substances in their states of aggregation as well as changes of selected physical values will be recorded and discussed.
### 3. Semester (Biochemical-Physical Direction)

#### Examination Block

<table>
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<tr>
<th>Number</th>
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</table>

**Abstract**


**Objective**

Classical tools to solve the most common linear partial differential equations.

1. Examples of partial differential equations
   - Classification of PDEs
   - Superposition principle

2. One-dimensional wave equation
   - D'Alembert's formula
   - Duhamel's principle

3. Fourier series
   - Representation of piecewise continuous functions via Fourier series
   - Examples and applications

4. Separation of variables
   - Solution of wave and heat equation
   - Homogeneous and inhomogeneous boundary conditions
   - Dirichlet and Neumann boundary conditions

5. Laplace equation
   - Solution of Laplace's equation on the rectangle, disk and annulus
   - Poisson formula
   - Mean value theorem and maximum principle

6. Fourier transform
   - Derivation and definition
   - Inverse Fourier transformation and inversion formula
   - Interpretation and properties of the Fourier transform
   - Solution of the heat equation

7. Laplace transform (if time allows)
   - Definition, motivation and properties
   - Inverse Laplace transform of rational functions
   - Application to ordinary differential equations

**Literature**


**Additional books:**

4. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons (chapters 1,2,11,12,6)

For additional sources, see the course web site (linked under Lernmaterialien)

**Prerequisites / notice**

Required background:

1. Multivariate functions: partial derivatives, differentiability, Jacobian matrix, Jacobian determinant
2. Multiple integrals: Riemann integrals in two or three variables, change of variables
3. Basic knowledge of ordinary differential equations

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### 529-0001-00L

**Introduction to Computer Science**

W 4 credits 2V+2U P. H. Hünenberger

**Abstract**

Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation.

**Objective**

Acquire a starting package concerning the computational aspects of natural sciences; discuss fundamentals of computer architecture, languages, algorithms and programming with an eye to their application in the area of chemistry, biology and material science.

**Content**

Lecture: Introduction to UNIX, introduction to C++ programming, data representation and processing, computational errors, algorithms and scaling, sorting and searching, numerical algorithms, algorithmic strategies, computer simulation, computer architecture, operating systems, programming languages, computer networks, databases, representation of chemical structures, molecular simulation; Exercises: Make students familiar with the UNIX operating system, C++ programming techniques, simple algorithms and computational applications in chemistry by means of exercise series at the computer.

**Lecture notes**

Script booklet (copies of powerpoint slides, in English), distributed at first or second lecture.

**Literature**

See: www.csms.ethz.ch/education/linfo

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1364 of 2416
The goal of this course is the acquisition of a basic repertoire of synthetic methods including important reactions of aldehydes, ketones, and carboxylic acids, and carboxylic acid derivatives. Particular emphasis is placed on the understanding of reaction mechanisms and the correlation between structure and reactivity. A deeper understanding of the concepts presented during the lecture is reached by solving the problems handed out each time and discussed one week later in the exercise class.

Introduction to Chemical Reaction Kinetics

Objective

Content

Prerequisites / notice

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the written exam, the results of the exercises are taken into account when evaluating the results of the exam (compulsory performance component, 12% of the exam mark; in case of repetition of the exam, the exercise marks from a previous semester can be kept).

For more information about the lecture: www.csms.ethz.ch/education/Infol

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Abstract


Lecture notes

Will be provided.

Literature


Prerequisites / notice

Voraussetzungen:

- Mathematik I und II
- Allgemeine Chemie I und II
- Physikalische Chemie I

529-0450-00L

Semester Project

In a semester project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic.

Objective

Students are accustomed to scientific work and they get to know one specific research field.

<table>
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<tr>
<th>Number</th>
<th>Type</th>
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529-0450-00L

Bachelor's Thesis

It completes the Bachelor program and consists of a scientific project carried out independently.

Objective

Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

Second and Third Year Additional Subjects

The Bachelor's programme in Interdisciplinary Sciences allows students to choose from any subject taught at a Bachelor level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the 2nd year. See the Programme Regulations 2018 for further details.

Other Electives ETH

Further combinations of compulsory elective subjects arising upon specific written request by the students and permission by the Director of studies.

Science in Perspective

Recommended Science in Perspective (Type B) for D-CHAB

Language Courses

see Science in Perspective: Language Courses ETH/UZH
### Interdisciplinary Sciences Bachelor - Key for Type

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<td>Dr</td>
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<tr>
<td>O</td>
<td>Compulsory</td>
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### Key for Hours

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<td>U</td>
<td>exercise</td>
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<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>practical/laboratory course</td>
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<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Interdisciplinary Sciences Master

The Master's programme in Interdisciplinary Sciences allows students to choose from any subject taught at the Master's level at ETH Zurich.

In consultation with the Director of Studies of Interdisciplinary Sciences, every student must establish his/her own individual study programme at the beginning of the Master's programme. See the Programme Regulations 2007/2020 for further details.

► Majors

The following list provides various Majors that can be chosen from: https://ethz.ch/content/dam/ethz/special-interest/chab/chab-dept/studies/documents/IN/WL_IN_SR19192101_EN.pdf

In addition it is possible to create an individual Major in accordance with the Programme Regulations (Art. 19 paragraph 3).

Selection of courses from entire course catalogue of ETH, according to individual study plan

► General Courses

Selection of courses from entire course catalogue of ETH, according to individual study plan

► Proseminars, Laboratory Courses, Research Projects and Sem. Papers

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-0020-00L</td>
<td>Research Project</td>
<td>W</td>
<td>20</td>
<td>20A</td>
<td>Professors</td>
</tr>
<tr>
<td>Abstract</td>
<td>In a research project students extend their knowledge in a particular field, get acquainted with the scientific way of working, and learn to work on an actual research topic. Research projects are carried out in a core or optional subject area as chosen by the student.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Students are accustomed to scientific work and they get to know one specific research field.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Selection of courses from entire course catalogue of ETH, according to individual study plan

► Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

see Science in Perspective: Language Courses ETH/UZH

► Master's Thesis

Only students who fulfill the following criteria are allowed to begin with their Master's thesis:

a. successful completion of the Bachelor's programme;

b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.

Duration of the Master's Thesis: 4 months.

In the Master's thesis students prove their ability to independent, structured and scientific working. The Master's thesis is usually carried out in a core or optional subject area as chosen by the student.

Duration of the Master's Thesis 6 months, possible only with permission of the Director of Studies.

In the Master Thesis students prove their ability to independent, structured and scientific working.

Interdisciplinary Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td></td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td></td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td></td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Interdisciplinary Brain Sciences Master

Core Modules

The Core Modules take place at University of Zurich: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Core-Modules.html

Elective Core Modules

Courses listed here take place at ETH Zurich.

Further courses and a complete list of the Elective Core Modules can be found here: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Elective-Core-Modules.html

Please register for ETH-courses at ETH Zurich, for UZH-courses at UZH.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1414-00L</td>
<td>Current Topics in Brain Research (HS)</td>
<td>W</td>
<td>1 credit</td>
<td>1.5K</td>
<td>I. Mansuy, further lecturers</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>Different national and international scientific guests are invited to present and discuss their actual scientific results.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td>To exchange scientific knowledge and data and to promote communication and collaborations among researchers. For students: Critical discussion of current research. Students aiming at getting a credit point for this colloquium choose one topic and write a critical essay on the presented research topic.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td>Different scientific guests working in the field of molecular cognition, neurochemistry, neuromorphology and neurophysiology present their latest scientific results.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td>no handout</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td>no literature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td>Some of the seminars will be shared with the Institute of Neuroinformatics (INI) of UZH.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1219-00L</td>
<td>Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Riener, O. Lambercy</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>Rehabilitation Engineering is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.</td>
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</tr>
<tr>
<td></td>
<td>Objective</td>
<td>Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution. This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td>Introduction, problem definition, overview Rehabilitation of visual function - Anatomy and physiology of the visual sense - Technical aids (glasses, sensor substitution) - Retina and cortex implants Rehabilitation of hearing function - Anatomy and physiology of the auditory sense - Hearing aids - Cochlea Implants Rehabilitation and use of kinesthetic and tactile function - Anatomy and physiology of the kinesthetic and tactile sense - Tactile/haptic displays for motion therapy (incl. electrical stimulation) - Role of displays in motor learning Rehabilitation of vestibular function - Anatomy and physiology of the vestibular sense - Rehabilitation strategies and devices (e.g. BrainPort) Rehabilitation of vegetative Functions - Cardiac Pacemaker - Phrenic stimulation, artificial breathing aids - Bladder stimulation, artificial sphincter Brain stimulation and recording - Deep brain stimulation for patients with Parkinson, epilepsy, depression - Brain-Computer Interfaces</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
To obtain in-depth knowledge of the theoretical foundations of SPM

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/for details.

Abstract

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/ for details.

Objective

To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Literature

Introductory Books:


Selected Journal Articles and Web Links:


Prerequisites / notice

VideoTact, ForeThought Development, LLC. http://my.execpc.com/?dwysocki/videotac.html

Target Group:

Students of higher semesters and PhD students of

- D-MAVT, D-TET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich

Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

227-0971-00L Computational Psychiatry W 3 credits 4S

K. Stephan

Abstract

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Objective

This course aims at bridging the gap between mathematical modelers and clinical neuroscientists by teaching computational techniques in the context of clinical applications. The hope is that the acquisition of a joint language and tool-kit will enable more effective communication and joint translational research between fields that are usually worlds apart.

Content

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/for details.

227-0969-00L Methods & Models for fMRI Data Analysis W 6 credits 4V

K. Stephan

Abstract

This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective

To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.
This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W 6</td>
<td>3 credits</td>
</tr>
</tbody>
</table>

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module IN404 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

Abstract
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective
Understanding of the characteristics of neuromorphic circuit elements.

Content
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retina and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differentiating, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Applied Analysis of Variance and Experimental Design

Number of participants limited to 100.

401-0625-01L

Applied Analysis of Variance and Experimental Design

W 5 credits 2V+1U L. Meier

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

151-0601-00L

Theory of Robotics and Mechatronics

Does not take place this semester.

W 4 credits 3G to be announced

Abstract
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Objective
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Content
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Lecture notes
available.

376-1681-00L

Ethics of Life Sciences and Biotechnology

Number of participants limited to 100.

W 3 credits 2V A. Blasimme, E. Vayena

Abstract
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences

Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

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**Internship**

Further information: https://www.neuroscience.uzh.ch/en/Master-Studies/Program/Internship.html

**Master’s Thesis and Exam**

Landscape Architecture Master

★ Compulsory Basic Courses

All basic courses (in terms of content and methodology linked to "Foundation Studio I") must be completed.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

Lectures, exercises and excursions serve as an introduction to atmospheric sciences, hydrology and soil science. Students gain a broad vision of the cutting edge topics that are being researched and studied at the Department of Environmental Systems Science at ETH, Eawag, WSL a.o. This will be the base for a future dialog between the field of landscape architecture and the field of sciences.

Objective

Students acquire basic knowledge in atmospheric sciences, hydrology and soil science:
- Understanding basic chemical and physical processes in the atmosphere that influence weather and climate
- Knowledge of water balance, principles of integral water management and climatic factors in the field of hydrology
- Fundamentals about the classification of soils, soil-forming processes, physical and chemical soil properties, soil biology and ecology, soil degradation and protection

Students develop an understanding of the relevance of these topics in the field of landscape architecture. Temporal and physical scale, research methods, units of measurement, lexicon, modes of representation and critical literature form the framework for the joint discourse.

Content

The course unit consists of the three courses "Climate", "Water" and "Soil", which are organized in modules.

Module 1 "Climate", 19.–23.09.2022
- Atmospheric dynamics: weather conditions, precipitation formation, weather forecast
- Climate physics: past and future changes in global climate and scenarios for Switzerland
- Land-climate dynamics: interaction between the land surface and the climate system
- Hydrology and water cycle: extreme precipitation, influence of climate change on the cryosphere

Module 2 "Water", 26.09.–30.09.2022
- Hydrological profile of the northern side of the Alps:
  - Alpine region (Grimsel area): dominate role of snow and ice, dangerous processes, liquefaction of the water balance in the wake of climate change, uses (hydropower) and conflicts of use, new images of the Alpine region
  - From the Alps to the Mittelland (locations along the Aare): Lake Thun (role of lakes in the water cycle, river and lake shore planning), Uttagen (conflicts of use between groundwater use, flood protection, revitalization and modes of transport) & Seeland (Jura water correction, conflicts of use in the Seeland)
  - Jura (Reigoldswil region): Jurassic landforms, water in the karst, water supply in the karst
- Hydrology and water cycle: extreme precipitation, influence of climate change on the cryosphere

Module 3 "Soil", 3.10.–7.10.22
- Introduction to soils: definition, function, formation, classification and mapping
- Soil physics: soil texture, soil structure, soil water potentials, hydraulic conductivity
- Soil chemistry and fertility: clay minerals and oxides, cation exchange capacity, soil pH, essential plant nutrients
- Soil biology and ecology: soil fauna and microflora, fungi, bacteria, food web, organic matter
- Soil degradation and threats to soil resources: erosion, compaction, sealing, contamination, salinization
- Practical aspects of soil protection

Lecture notes

The course material includes a reading list.

Literature

The course material will be provided.

Prerequisites / notice

The courses "Climate", "Water" and "Soil" are organized with the Fundamental Studio I as joint one-week modules. The weekly schedules will be provided with the course materials.

Module 1 "Climate", 19.–23.09.2022
Module 2 "Water", 26.09.–30.09.2022
Module 3 "Soil", 3.10.–7.10.22

- The courses are held in English or German.
- The written session examination covers all three courses "Climate", "Water" and "Soil".
- During the excursions there will be at least one external overnight stay.

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
  - Decision-making assessed
  - Media and Digital Technologies assessed
- Social Competencies
  - Communication assessed
  - Cooperation and Teamwork assessed
- Personal Competencies
  - Creative Thinking assessed
  - Critical Thinking assessed
  - Integrity and Work Ethics assessed
  - Self-awareness and Self-reflection assessed
Abstract
This course introduces ecology and plant sciences. Through lectures, exercises and excursions, students will gain a broad vision of the cutting edge topics that are being researched and studied at the Department of Environmental Systems Science at ETH. This will be the base for a future dialogue between the field of landscape architecture and the field of sciences.

Objective
Students acquire basic knowledge in ecology and plant sciences focusing in its application in the field of landscape architecture. Temporal and physical scale, research methods, units of measurement, lexicon, modes of representation and critical literature form the framework for the joint discourse.

Content
The fundamental course “Ecology and Plant Sciences” is an introduction to the field of living systems, starting with the history of ecology, followed by an introduction to plant systematics, taxonomy and physiology. The course will also introduce students to the specifics of the rhizosphere, disturbance ecology and forests. Lastly, the course will focus on the specifics of tree structure and function.

Lecture notes
Course material will be provided.

Literature
The course material includes a reading list.

Prerequisites / notice
The fundamental course is organized with the Fundamental Studio I as a joint two-week module. The weekly schedule is provided with the course documents.

Module 4 ”Ecology and Plant Sciences”, 10.10.–21.10.2022

Fostered competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed
Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
Social Competencies
- Communication assessed
Personal Competencies
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed

Designing with Plants I
Only for Landscape Architecture MSc.

Abstract
This fundamental course provides an introduction to the basics of botany and forms a solid foundation of knowledge for the following semesters. The course covers the following areas: Species knowledge of native shrubs and trees in autumn and winter conditions and their habitat requirements, introduction to the identification of plants and consolidation of botanical terms.

Objective
Students will be introduced to botany and after the course they will be able to identify about sixty native trees and shrubs in order to use them appropriately in their designs. They will be familiar with botanical terms, which will enable them to have a high level of understanding of botanical literature.

Content
This course focuses on excursions with a botanical expert. In addition, the students are supported by theoretical and conceptual lectures. This gives the students a good basis of botanical knowledge, which can be professionally integrated into their designs. This module is organized together with the Foundation Studio I, so that the knowledge imparted can directly influence the designs.

The module is divided into different subject areas:

1) Consolidation of botanical terms. These form the basis for the identification and recognition of plants. The most important technical terms are explained and illustrated with suitable plant material.

2) Species knowledge is taught on regular field excursions and supplemented with theoretical input. The species can also be studied in the classroom using fresh material. In addition to site characteristics and seasonal changes, growth forms are also taught.

3) Through the introduction to identification, the students will understand how a simple identification key is constructed and how it is used, so that unknown species can be identified independently.

The fundamental course Designing with Plants I (31st October – 3rd November 2022) and the Foundation Studio I are interrelated modules. The weekly schedule is published on the course website (and is included in the reader).

Lecture notes
The notes or reader will be distributed during the course.

Literature
The relevant literature and content for the examination will be indicated during the course.

Prerequisites / notice
The course is aimed exclusively at the students of the master's programme in landscape architecture.

The detailed course schedule is published on the course website (and is included in the reader).

The lectures might take place outside. It is necessary to foresee clothes adapted to the weather.
The detailed course schedule is provided at the beginning of the semester and is included in the reader notice.
### Fostered competencies

<table>
<thead>
<tr>
<th>Course</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethics in Landscape Architecture</td>
<td>Concepts and Theories</td>
<td>Decision-making</td>
<td>Communication</td>
<td>Adaptable and Flexibility</td>
</tr>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
</tr>
<tr>
<td>Digital Design Methods I</td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Self-presentation and Social Influence</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Sensitivity to Diversity</td>
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<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Self-presentation and Social Influence</td>
<td>Self-presentation and Social Influence</td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Leadership and Responsibility</td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Self-presentation and Social Influence</td>
<td>Self-presentation and Social Influence</td>
</tr>
</tbody>
</table>

### Abstract

This course covers basic positions of philosophical ethics with a strong emphasis on central debates in landscape architecture.

### Objective

The course aims to provide basic knowledge of concepts and terms within moral philosophy; engage with current debates in landscape architecture through lectures, text analysis, discussions and presentations; develop an understanding of the relation between science/society/design as well as practice and theory; help establish one's own design attitude; provide tools for argumentation; put to practice scientific working methods.

### Content

Between the poles of theory and practice and through the development of a foundation in ethics, the students' sensitivity for ecological, political and social issues will be awakened and strengthened. In response to current issues touched upon in the disciplinary media or journalism, we will reflect upon the role of landscape architects in today's society as well as one's own individual attitude within the profession. The overall goal is for students to gain a critical understanding of a range of design approaches as well as an awareness of the specific role of design and design quality in the context of ethical debates.

Texts will be read in German and English.

### Lecture notes

Detailed information regarding the course will be communicated at the beginning of the semester.

### Literature

The course material includes a reading list.

### Prerequisites / notice

The course takes place as a block course alternating with "History and Theory of Landscape Architecture I".

---

**Core Courses**

Data: 01.11.2022 12:41   Autumn Semester 2022   Page 1375 of 2416
The core courses build on the basic courses and convey basic, broad knowledge in the core areas of landscape architecture in relation to design lessons. Some of the core courses are compulsory and some are freely selectable. Further details, in particular about taking these subjects, for performance assessments and for compensating for failed subjects, are regulated in Art. 27 and Art. 31 Paragraph 4.

**Compulsory Core Courses**

Courses are offered in Spring Semester.

**Elective Core Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>052-0717-22L</td>
<td>Territory of the City: Turin</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>G. Vogt</td>
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</tbody>
</table>

**Abstract**
The elective deals with current transformation processes of metropolitan landscapes in Europe and introduces landscape architecture design on a territorial scale. On the basis of cartographic analysis and field trips, students will develop concrete strategies for the urban landscape of the Città Metropolitana di Torino.

**Objective**
The elective introduces to the subject and complexity of the urbanized landscape and teaches the critical engagement with the challenges and potentials of current tendencies in Landscape Architecture. On the basis of a concrete study area, students examine the large-scale processes of reuse, reform and reinterpretation of metropolitan landscapes in Europe and develop new approaches and strategies on various scales.

**Content**

**Lecture notes**
A workbook with texts and background information is available for purchase (CHF 20.-). A digital version is also available for free.
The internship report should cover as many work phases as possible in the work of a landscape architect.

Analytical Competencies

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<tr>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td></td>
<td>T. Gali-Izard, G. Vogt</td>
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<tr>
<td>Techniques and Technologies</td>
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Method-specific Competencies

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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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Social Competencies

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<th>Type</th>
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<tr>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tr>
<td>Negotiation</td>
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Personal Competencies

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<tr>
<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
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Advanced Studio

Complex design tasks involving social, topographical, hydrological and ecological issues.

Seminar Week and Internship Report

In MScLA at least one week of seminar must be completed. Furthermore, part of the course is a six-month internship in the field of landscape architecture, the achievements (work phases, learning success) must be documented in an internship report.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>061-0153-00L</td>
<td>Internship Report</td>
<td>O</td>
<td>2</td>
<td>4P</td>
<td>T. Gali-Izard, G. Vogt</td>
</tr>
<tr>
<td>Abstract</td>
<td>Part of the course is a six-month internship in the field of landscape architecture. The internship should include as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.</td>
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<tr>
<td>Objective</td>
<td>The internship report should cover as many work phases as possible in the work of a landscape architect.</td>
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<tr>
<td>Content</td>
<td>The internship report should cover as many work phases as possible in the work of a landscape architect. The internship should include as many work phases as possible in the work of a landscape architect. The students prepare an internship report in which they describe the various internship activities in detail and reflect on the learning success.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Internship report (of 6 months, within the field of landscape architecture). The report can be written in German or English language.</td>
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</table>

061-0151-22L Seminar Week Autumn Semester 2022

Does not take place this semester.

Only for Landscape Architecture MSc.

Abstract

Along five walks we explore the city vegetation of Basel and built connections to the conditions of the surrounding landscape. Obtaining a panoptical view of the “nature of the city” is the goal of intensive study of the territory.

Objective

In addition to an comprehensive insight into the vegetation of the city of Basel, the students receive an introduction to the method of walking as a way of exploring the urban landscape from a pedestrian perspective.

Content

Five walks lead us through the territory of the city of Basel. The tri-national area (Germany, Switzerland, France) with its exceptional geological, topographical, hydrological and climatic situation has a specific and diverse vegetation. We discover this diversity on the walks in the Petite Camargue, on the Tüllinger Hügel, during the crossing of the Jura and in the parks within the city.

The walks are led by proven experts. In conversations, Sonja Hassold (biologist), Günther Vogt (landscape architect) and Markus Ritter (ecologist) explain the relationships between the vegetation found and the conditions of the landscape. In doing so, references are made to the political, social and economic influencing factors that regulate the development of the landscape and significantly influence its shape.

The program is contextualized by dealing with the topic of walking science. Markus Ritter introduces the theory and method of promenadology in evening lectures, seminars and reading sessions, focusing on the person of Lucius Burckhardt (sociologist, 1925 - 2003).

The reader will be given at the introductory course.

All relevant literature is included in the reader.

The weekly schedule is included in the reader.

The costs for the seminar trip (24.10.-30.10.) range between 251.- and 500.- (cost framework B). Included are: All overnight stays (including breakfast), a dinner together, transfers from the hotel to the excursions, reader and all costs for admission to museums.

The course is aimed exclusively at students of the master's program in landscape architecture.

It is highly recommended to participate this Seminar Week in preparation for the Module 5 (061-0105-00L Designing with Plants I) and the lecture Designing with Plants II (061-0106-00L)
Fostered competencies
Subject-specific Competencies
- Concepts and Theories - assessed
- Techniques and Technologies - assessed

Method-specific Competencies
- Analytical Competencies - assessed
- Decision-making - assessed
- Media and Digital Technologies - assessed
- Problem-solving - assessed
- Project Management - not assessed

Social Competencies
- Communication - assessed
- Cooperation and Teamwork - not assessed
- Customer Orientation - not assessed
- Leadership and Responsibility - not assessed
- Self-presentation and Social Influence - not assessed
- Sensitivity to Diversity - assessed
- Negotiation - assessed

Personal Competencies
- Adaptability and Flexibility - assessed
- Creative Thinking - assessed
- Critical Thinking - assessed
- Integrity and Work Ethics - not assessed
- Self-awareness and Self-reflection - assessed
- Self-direction and Self-management - not assessed

Science in Perspective
Courses of the "Science in Perspective" programme have to be completed (details see study guidelines Art. 27).

Recommended Science in Perspective (Type B) for D-ARCH
see Science in Perspective: Type A: Enhancement of Reflection Capability

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis
The master's thesis is the successful completion of the course. It confirms the ability to work independently in the field of landscape architecture and is tutored by D-ARCH professors (for details see Art. 30 of the study regulations).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>061-0900-00L</td>
<td>Master's Thesis (*)</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract
Is offered as of HS22 only.

Prerequisites / notice
The Master Thesis in Landscape Architecture begins 5th September 2022 and ends 12th December 2022.

Landscape Architecture Master - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>W+</td>
<td>E</td>
<td>Recommended, not eligible for credits</td>
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<td>O</td>
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<td>Courses outside the curriculum</td>
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<td>W</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

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<tr>
<th>Key for Hours</th>
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Special students and auditors need special permission from the lecturers.

ECTS European Credit Transfer and Accumulation System
### Educational Science

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tbody>
<tr>
<td>851-0240-00L</td>
<td>Human Learning (EW1)</td>
<td>E</td>
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<td>E. Stern</td>
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<td>This course looks into scientific theories and also empirical studies</td>
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<td>on human learning and relates them to the school.</td>
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<td>Anyone wishing to be a successful teacher must first of all understand</td>
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<td>the learning process. Against this background, theories and findings</td>
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<td>on the way humans process information and on human behaviour are</td>
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<td>prepared in such a manner that they can be used for planning and</td>
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<td>conducting lessons. Students additionally gain an understanding of what</td>
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<td>is going on in learning and behavioural research so that teachers</td>
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<td>are put in a position where they can further educate themselves in the</td>
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<td>field of research into teaching and learning.</td>
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<td>Thematicische Schwerpunkte:</td>
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<td>Lernen als Verhaltensänderung und als Informationsverarbeitung:</td>
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<td>Das menschliche Gedächtnis unter besonderer Berücksichtigung der</td>
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<td></td>
<td>Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion</td>
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<td></td>
<td>und Kompetenzerwerb unter besonderer Berücksichtigung des Wissensstrahls;</td>
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<td>Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und</td>
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<td></td>
<td>Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit</td>
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<td></td>
<td>und ihre Ursachen: Intelligenztheorien, Geschlechtsunterschiede beim Lernen</td>
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<td>Lernformen: Theorien und wissenschaftliche Konstrukte werden zusammen</td>
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<td>mit ausgewählten wissenschaftlichen Untersuchungen in Form einer</td>
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<td>Vorlesung präsentiert. Die Studierenden vertiefen nach jeder Stunde die</td>
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<td>Inhalte durch die Bearbeitung von Aufträgen in einem elektronischen</td>
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<td>Lerntagebuch. Über die Bedeutung des Gelernten für den Schulalltag soll</td>
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<td>reflektiert werden. Ausgewählte Tagebuchbeiträge werden zu Beginn jeder</td>
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<td>Vorlesung thematisiert.</td>
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<td>Folien werden zur Verfügung gestellt.</td>
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<td>1) Marcus Hasselhorn &amp; Andreas Gold (2006). Pädagogische Psychologie:</td>
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<td>Prentice Hall. 3) Greutmann, Saalbach, Stern (Hrsg.), (2020):</td>
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<td>Professionelles Handlungswissen für Lehrerinnen und Lehrer. Kohlhammer</td>
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<td>This lecture is only apt for students who intend to enrol in the</td>
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<td>programs &quot;Lehrdiplom&quot; or &quot;Didaktisches Zertifikat&quot;. It is about learning</td>
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<td>in childhood and adolescence.</td>
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<td>This course unit can only be enrolled after successful participation in</td>
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<td>or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<td>This seminar focuses on teaching units in chemistry, physics and</td>
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<td>mathematics that have been developed at the MINT Learning Center of</td>
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<td>the ETH Zurich. In the first meeting, the mission of the MINT Learning</td>
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<td>Center will be communicated. Furthermore, in groups of two, the students</td>
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<td>will intensively work on, refine and optimize the teaching unit following</td>
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<td>a goal set in advance.</td>
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<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td>- Get information about recent literature on learning and instruction</td>
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<td>Für eine reibungslose Semesterplanung wird um frühe Anmeldung und</td>
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<td>persönliches Erscheinen zum ersten Lehrveranstaltungstermin erfu-</td>
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<tr>
<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
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<td>2S</td>
<td>R. Schumacher</td>
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<td>Enrolment only possible with matriculation in Teaching Diploma or</td>
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<td>Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td>851-0242-07L</td>
<td>Human Intelligence</td>
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<td>1S</td>
<td>E. Stern</td>
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<td>Enrolment only possible with matriculation in Teaching Diploma or</td>
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<td>Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<td>Number of participants limited to 30.</td>
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<td>This course unit can only be enrolled after successful participation in</td>
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<td></td>
<td>or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>C. M. Thurn, T.</td>
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<td></td>
<td>Number of participants limited to 30.</td>
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<td>Braas, P.</td>
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<td>This course unit can only be enrolled after successful participation in</td>
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<td>or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td>851-0240-22L</td>
<td>Coping with Psychosocial Demands of Teaching (EW4 W DZ)</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>U. Markwalder,</td>
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<td></td>
<td>Number of participants limited to 20.</td>
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<td>S. Maurer,</td>
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<tr>
<td></td>
<td>The successful participation in EW1 (&quot;Human Learning&quot;)</td>
<td></td>
<td></td>
<td></td>
<td>S. Peteranderl-Rüschoff</td>
</tr>
</tbody>
</table>
In this class, students will learn concepts and skills for coping with psychosocial demands of teaching

Objective
Students possess theoretical knowledge and practical competencies to be able to cope with the psychosocial demands of teaching.

(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-9020-00L</td>
<td>Teaching Internship Including Examination Lessons Food Science</td>
<td>W</td>
<td>6 credits</td>
<td>13P</td>
<td>G. Kaufmann</td>
</tr>
</tbody>
</table>

Abstract
The teaching internship can just be visited if all other courses of TC are completed.

Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

Number of participants limited to 30.

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract
In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

Objective
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues.
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

Content
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

* Subject Didactics and Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.
**Further Subject Didactics**

*For students enrolled from HS 2019: The courses offered here are credited under the category «Subject Didactics and Professional Training».*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-9005-00L</td>
<td>Mentored Work Specialised Courses in the Respective Subject with an Educational Focus Food Sc.</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>G. Kaufmann, K. Koch, U. Lerch</td>
</tr>
</tbody>
</table>

**Abstract**

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

**Objective**

The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

**Content**

Thematic Schwerpunkte:


Lernformen:


**Lecture notes**

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

**Literature**

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

**Prerequisites / notice**

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

---

**Food Science TC - Key for Type**

| O  | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z  | Courses outside the curriculum |
| W  | Eligible for credits | Dr | Suitable for doctorate |

**Key for Hours**

| V  | lecture | P | practical/laboratory course |
| G  | lecture with exercise | A | independent project |
| U  | exercise | D | diploma thesis |
| S  | seminar | R | revision course / private study |
| K  | colloquium | |

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-3103-00L</td>
<td>Food Rheology I</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>P. A. Fischer</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, basis measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Notes will be handed out during the lectures.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Provided in the lecture notes.</td>
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<tr>
<td>752-2003-00L</td>
<td>Selected Topics in Food Technology</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>R. Stadler, C. Bolten</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Part 1 of the course deals with global market trends, food technologies, food health benefits. Physical and chemical fundamental knowledge help grasp the molecular composition of food. Part 2 entails management of risks across the food supply chain. The focus is on technological solutions to mitigate hazards, as well as their management upstream.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The objectives of the course are for students to understand the key drivers (market and consumer trends, health benefits, sustainability, etc.) that impact innovation in a food business environment. The course also illustrates food safety and quality considerations across the whole supply chain, using concrete examples and how certain technologies assist in reducing or eliminating food safety risks.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.</td>
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<tr>
<td><strong>Literature</strong></td>
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<tr>
<td>752-2314-00L</td>
<td>Physics of Food Colloids</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>P. A. Fischer, R. Mezzenga</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>In Physics of Food Colloids the principles of colloid science will applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Provided in the lecture notes.</td>
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<tr>
<td>752-3021-00L</td>
<td>Food Process Design and Optimization</td>
<td>W+</td>
<td>4 credits</td>
<td>2G</td>
<td>E. J. Windhab</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>S-PRO2 scheme and quantitative understanding of process-structure functions. Process characterisation by dimension analysis. Optimization aspects/criteria for stirring, mixing, dispersing, spraying and extrusion flow processes of multiphase multi-scale structured food systems. Up- and down-scaling and industrial applications. Training by case studies from research and industrial production.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Quantitative process analysis and derivation of process-structure functions for complex liquid or semi-liquid food systems with non-Newtonial flow properties. Handling of optimisation and up-/down-scaling procedures.</td>
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<tr>
<td><strong>Content</strong></td>
<td>S-PRO2 scheme, reverse engineering approach, dimension analysis. Metzner-Otto and Rieger Novack design schemes of stirred reactors for non-Newtonian fluid processing, mixing/mixing statistics, mixing characteristics, power charac-teristics, dispersing characteristics, dispersing processes in rotor/stator and membrane devices, spray processing, extrusion processing, diverse case studies for design and scaling of processes for food structure processing.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>printed handouts (ca. 180)</td>
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<tr>
<td><strong>Literature</strong></td>
<td>List of ca. 30 papers and 5 books given in course</td>
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<tr>
<td>752-3023-00L</td>
<td>Process Measurements and Automation</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>E. J. Windhab</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Overview on Process Automation, Information Management in processes, process data handling and analysis. In-line measurements of complex food systems, Process control schemes, Overview of sensors and sensor principles, integrated process control case studies</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Understanding the interplay of in-line measurements of complex food properties in processes, process data handling and data analysis as well as building blocks for process control.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Overview Process Automation, Process Control and process data management, Industrial design of automated/controlled processes, overview on sensors/sensor principles, case studies of in-line measurements and control in/of food production processes</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Printed script (120 pages, 80 figures), diverse publications</td>
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<tr>
<td><strong>Literature</strong></td>
<td>List of publications and books given in course</td>
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<tr>
<td>752-3201-00L</td>
<td>Emerging Thermal and Non Thermal Food Processing</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Mathys, J. Dummer</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course is built on the holistic approach in sustainable food processing via the consideration of the total value chain. Selected mechanical, biotechnological, thermal and non-thermal techniques for best biomass and energy use efficiency will be investigated. Focused techniques are new thermal processes, high pressure techniques, electroproportion and different radiation based sources.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Understanding of selected emerging food processing concepts with focus on lower process intensity for healthy and high quality food production, waste reduction as well as biomass and energy use efficiency. Updates from academia and industry around new trends in food process development.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Emerging combined processes based on mechanical, thermal and non-thermal techniques, Multi hurdle technology concept for preservation, Extreme high temperature-short time processes, high pressure techniques, electroproportion, radiation, Biorefineries based on emerging process elements, Ongoing industry initiatives</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Script will be distributed before the course via Moodle.</td>
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</tbody>
</table>
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of

5 credits

Title
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual

2V+1U

M. Dettling

Lecturers
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear

A script will be available.

Lecture notes
Faraway (2005): Linear Models with R

Faraway (2006): Extending the Linear Model with R

Draper & Smith (1998): Applied Regression Analysis

Fox (2008): Applied Regression Analysis and GLMs

Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for

Methodology Subjects

Number  |
---|---
401-0625-01L  |

Title  |
**Applied Analysis of Variance and Experimental Design**

ECTS  |
5 credits

Type  |
W+

Hours  |
2V+1U

Lecturers  |
L. Meier

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

401-0649-00L  |

Title  |
**Applied Statistical Regression**

ECTS  |
5 credits

Type  |
W+

Hours  |
2V+1U

Lecturers  |
M. Dettling

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R

Faraway (2006): Extending the Linear Model with R

Draper & Smith (1998): Applied Regression Analysis

Fox (2008): Applied Regression Analysis and GLMs

Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Sustainable Food Processing Brijesh K. Tiwari (Editor), Tomas Norton (Editor), Nicholas M. Holden (Editor) ISBN: 978-0-470-67223-5 600 pages December 2013, Wiley-Blackwell


Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1383 of 2416
Fostered competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies

- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed

Social Competencies

- Communication assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies

- Adaptability and Flexibility assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

Optional Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-3105-00L</td>
<td>Physiology Guided Food Structure and Process</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>E. J. Windhab, M. Devzeaux de Lavergne, B. von der Weid, T. Wooster</td>
</tr>
</tbody>
</table>

Abstract

A “cook-and look” approach to process design is no longer applicable in the current environmental, nutritional and competitive constraints. The modern R&D chemical/food engineer should have a clear focus on the desired structure that needs to be achieved to design a process line or a processing equipment, coupled with in depth knowledge of the processed materials.

Objective

The objective of this course is to highlight the intimate links between human physiology and product sensory and nutritional functions. To optimize these functions, an understanding of the physiological functions that interact and encode the actions of those product structures must be well understood.

Therefore the objective of this course is for students to be equipped with a skill set that will encompass basic digestion and sensory physiology knowledge and food structures.

The students will be exposed to this interplay all along the GI tract, including taste, aroma and texture perception, swallowing mechanics and gastro intestinal digestion with an engineering or physical sciences angle.

Major in Food Quality and Safety

Disciplinary Subjects

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-0801-00L</td>
<td>Food Law and Legislation</td>
<td>W+</td>
<td>1 credit</td>
<td>1V</td>
<td>K. Krell Zbinden, E. Zbinden Kaessner</td>
</tr>
</tbody>
</table>

Abstract

Introduction to the principles of the EU and international Organisations, Principles of the Swiss food law.

Objective

Knowledge of the principles and the structure of the EU in general and in the area of food safety, overview of the relevant bilateral agreements CH-EU as well as on the most important international organisations (Codex Alimentarius and WTO) and their influence on the Swiss regulations on food safety.

Analytical data and premises and their equipment can be judged in the legal context of food law.

Content

General introduction into the EU and in the area of food safety (regulation on food safety), legislative procedures in the EU, introduction into the relevant bilateral agreements CH-EU, introduction into international organisations (e.g. Codex Alimentarius), general principles of the Swiss food law and the most important regulations as well as the most important legal procedures, legal settlement and the duties and responsibilities of the Food control authorities.

Lecture notes

Copies of the presentations will be handed out.

Literature

Documents about Codex Alimetarius, the EU regulation as well as the Swiss food law and some regulations will be handed out.

Prerequisites / notice

Qualifications: General knowledge of the food sciences.

The lecture will be held in German.

752-1021-00L | Food Enzymology | W+ | 3 credits | 2G  | L. Nystöm, M. Erzinger |

Abstract

The course covers the fundamentals of food enzymology, application of endogenous and exogenous enzymes in food processing, as well as use of enzymes in analytics.

Objective

Students can describe what enzymes are and can explain their use and functions in food and food products. Students can argue why and how enzymes are used in food processing and analysis.

Students execute a research project independently and defend their findings during a presentation to peer students and an expert panel.

Content

Enzymes in foods: the use of added enzymes in food processing, control and/or utilization of endogenous enzymes, production of enzyme preparations for food use, and chemical analysis of food components by enzymatic methods.

Course contains lectures and a practical group work.

Lecture notes

The lectures are supplemented with handouts.

Prerequisites / notice

Course prerequisites: Food Chemistry I/II and Food Analysis I/II (or equivalent)
752-4009-00L Molecular Biology of Foodborne Pathogens W+ 3 credits 2V M. Loesener, M. Schmelcher, M. Schuppler, E. Wetter Slack

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to integrate with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-5103-00L Functional Microorganisms in Foods W+ 3 credits 2G C. Lacroix, A. Geinaert, A. Greppi

Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

Lecture notes
Copy of the power point slides from lectures will be provided.

Literature
A list of topics for group projects will be supplied, with key references for each topic.

Prerequisites / notice
This lecture requires strong basics in microbiology.

752-1301-00L Special Topics in Toxicology W 2 credits 2G K. Hecht, F. Michailidou

Abstract
Journal-club style course involving student presentations and active discussion and critique of recent publications and modern experimental strategies. The focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester

Objective
- to stimulate student interest and provide advanced knowledge of current research in Toxicology and its related sciences
- to develop skills in critical evaluation of scientific literature, oral presentation and questioning
- to understand modern experimental techniques and research approaches relevant in toxicology

Content
The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

Literature
A selection of approximately 20 papers from recent primary scientific literature.
Methodology Subjects

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
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<tr>
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<td>Abstract</td>
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<td></td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W+</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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<td>Abstract</td>
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<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning &quot;good practice&quot; that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<td>The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.</td>
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<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.</td>
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<td>Faraway (2005): Linear Models with R</td>
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<td>Fox (2008): Applied Regression Analysis and GLMs</td>
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<td>Montgomery et al. (2006): Introduction to Linear Regression Analysis</td>
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<td>Prerequisites / notice</td>
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<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.</td>
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In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

Prerequisites / notice

For Masters level participants, a strict prerequisite is (a) previously taken and passed "Introduction to Toxicology" (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for "Advanced Topics in Toxicology". It is only possible to take one, and it is only possible to take the advanced level after completing this course.

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Learn to apply practical bioinformatics/computational skills for analysis of microorganisms in foods and human health! Students will apply basic programming skills for scientific computing and bioinformatics, and learn and discuss the importance of microorganisms to foods and human health, through recognition and comparison of ecological theory, methodology, and experimental design across systems.

Learn to apply bioinformatics and computational methods for analysis of microbiome next-generation sequencing data. A secondary goal is to critically examine the relevance of microbiomes to quality, safety, and human health, through application of theory and appropriate experimental design. Students completing this course will thus be able to both apply appropriate methodology to study microorganisms (or other high-dimensional data) in different systems, as well as evaluate and interpret bioinformatics results.
## Optional Subjects

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>F. Constancias, G. Brogini, S. Bull, A. Greppi, F. Orelli</td>
</tr>
<tr>
<td>752-1302-00L</td>
<td>Advanced Topics in Toxicology</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>F. Michaillidou, S. J. Sturlia</td>
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<tr>
<td>376-1353-00L</td>
<td>Nanostructured Materials Safety</td>
<td>W</td>
<td>2 credits</td>
<td>1V</td>
<td>P. Wick</td>
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</table>

### Prerequisites / notice

**Gene Technology in Foods**
- Only for students who have previously taken "Special Topics in Food Toxicology" (752-1301-00L).
- Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.

**Advanced Topics in Toxicology**
- Participants are required to have completed previously "Special Topics in Toxicology" (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for "Advanced Topics in Toxicology" until after you have completed "Special Topics in Toxicology"

**Nanostructured Materials Safety**
- Course "Introduction to Toxicology"
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies. The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

**Nutritional Aspects of Food Composition and Processing**

**Objective**
Students should be able to:
- describe and compare the major concepts/criteria used for the evaluation of the nutritional quality of food
- apply these criteria when assessing the effects of selected processing technologies on nutritional quality.

**Content**
The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.

**Prerequisites / notice**
The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Critical Thinking

**Dietary Etiologies of Chronic Disease**

**Abstract**
To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Objective**
To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic diseases, as well as the progression of complications of the chronic diseases.

**Content**
The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

**Prerequisites / notice**
No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Critical Thinking

**Epidemiology and Prevention**

**Abstract**
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

**Objective**
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

**Content**
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories
- Method-specific Competencies: Analytical Competencies
- Personal Competencies: Critical Thinking

**Applied Analysis of Variance and Experimental Design**

**Abstract**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Objective**
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**

**Applied Statistical Regression**

**Abstract**
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

A script will be available.

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

A script will be available.

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
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Montgomery et al. (2006): Introduction to Linear Regression Analysis

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

This course requires extensive engagement in learning outside of the classroom (using online resources and practical exercises), with a focus on active learning in the classroom.

Students will bring and work on their own laptop computers.

All software used in the course is free and open-source.

- **Concepts and Theories**
- **Techniques and Technologies**
- **Analytical Competencies**
- **Decision-making**
- **Media and Digital Technologies**
- **Problem-solving**
- **Project Management**
- **Communication**
- **Cooperation and Teamwork**
- **Customer Orientation**
- **Leadership and Responsibility**
- **Self-presentation and Social Influence**
- **Sensitivity to Diversity**
- **Adaptability and Flexibility**
- **Creative Thinking**
- **Critical Thinking**
- **Integrity and Work Ethics**
- **Self-awareness and Self-reflection**
- **Self-direction and Self-management**

#### Optional Subjects

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>752-5103-00L</td>
<td>Functional Microorganisms in Foods</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>C. Lacroix, A. Geirnaert, A. Greppi</td>
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</tbody>
</table>
Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.

- Legal and protection issues related to functional foods

- Industrial biotechnology of flavor and taste development

- Safety of food cultures and probiotics

Lecture notes
Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Literature
A list of topics for group projects will be supplied, with key references for each topic.

Prerequisites / notice
This lecture requires strong basics in microbiology.

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752-6301-00L Nutrition-Related Physiology

<table>
<thead>
<tr>
<th>Content</th>
<th>Objective</th>
<th>Literature</th>
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<tbody>
<tr>
<td>Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.</td>
<td>This lecture requires strong basics in microbiology.</td>
<td>Copy of the power point slides from lectures will be provided.</td>
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752-6403-00L Nutrition and Performance

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<th>Content</th>
<th>Objective</th>
<th>Literature</th>
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<tr>
<td>The course introduces basic concepts of the interaction between nutrition and exercise performance.</td>
<td>To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during and after exercise</td>
<td>Lecture slides and required handouts will be available on the ETH website (moodle).</td>
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752-5111-00L Gene Technology in Foods

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<th>Content</th>
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<tr>
<td>This course will increase basic knowledge on biotechnological constructions and application of genetically modified organisms (GMO) which are used worldwide in food production systems. The course discusses health issues, the legislation frame and food safety aspects of GMO applications in agriculture, food production and consumption in Switzerland and EU-countries.</td>
<td>This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of GMO, especially on the molecular basis of GMO constructions with emphasis on genetically modified food in Switzerland and the EU.</td>
<td>Information on further reading will be announced during the lecture. There will be some mandatory as well as voluntary readings.</td>
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752-1301-00L Special Topics in Toxicology

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<tr>
<th>Content</th>
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<tr>
<td>The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).</td>
<td>To stimulate student interest and provide advanced knowledge of current research in Toxicology and its related sciences. To develop skills in critical evaluation of scientific literature, oral presentation and questioning. To understand modern experimental techniques and research approaches relevant in toxicology.</td>
<td>A selection of approximately 20 papers from recent primary scientific literature.</td>
</tr>
</tbody>
</table>
The objectives of this practical course include learning about and experiences with analytical methods to determine macro- and micronutrient content in foods, critical evaluation of analytical results, critical comparison with values from food composition tables, and interpretation in relation to nutritional value of meals. The nutritional values of the meals are discussed, as well as their relation to specific chronic diseases and iron bioavailability. Discussion is facilitated by an oral presentation with colloquium and a written report.

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommended to view the online R course EbisPro and then critically evaluated.

The practical course Nutrient Analysis in Foods includes meal preparation (a half day early December 2022; date to be defined) and chemical analysis of five meals from five different types of diets (students will work in groups; one meal per group). The content of macronutrients, specific micronutrients and secondary plant components (polyphenols and phytic acid) are analysed using common analytical methods. The analytical results are compared with calculated data from food composition databases using the nutrition software EbisPro and then critically evaluated.

Students will work in groups, and will assess one group per meal. Performance will be assessed by means of:
1) Contribution to laboratory practical work (30.01.2023 - 8.02.2023);
2) A written test on course content (via Moodle, completed by 10.02.2023);
3) A 15 min oral presentation of laboratory results in a seminar with colloquium (active discussion) (17.02.2023);
4) A 5-page written report per group (deadline 24.02.2023).

The module Public Health is compulsory for all students in the major Human Health, Nutrition and Environment.

This course covers the main methods used in Biostatistics. It starts by revising Linear Models (Regression, Anova), then moves to Generalised Linear Models (logistic regression and methods for count data) and finally introduces more advanced topics (Linear Mixed-Effects Models and Generalised Additive Models). The course strongly focuses on applied aspects of data analysis.

This course is structured into three parts. The first part focuses on Linear and Generalised Linear Models. The second part introduces more advanced methodologies such as Linear Mixed-Effects Models and Generalised Additive Models. Both, part one and two will include the following topics: exploratory data analysis, model fitting, model "selection", residual diagnostics, model validation and results interpretation. Analyses will be carried out using the statistical software R. Finally, in the third part of the course students will be analysing real-world datasets to put into practice the knowledge and skills acquired during the first two parts.

The statistical software R will be used in the exercises. If you are unfamiliar with R, it is highly recommended to view the online R course "Rcourse".
Module Infectious Diseases

Number   Title                                    Type   ECTS   Hours   Lecturers
701-1703-00L Evolutionary Medicine for Infectious Diseases W  3 credits  2G    A. Hall

Number of participants limited to 35.
Waiting list will be deleted 02.10.2022.

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antimicrobial resistance, (v) evolution-proof medicine. For each topic there will be a short (< 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:
Schmid Hempel 2011 Evolutionary Parasitology
Stearns & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.
Abstract
This course provides a detailed understanding of - development of T and B cells - the dynamics of a immune response during acute and chronic infection - mechanisms of immunopathology - modern vaccination strategies
Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.

Objective
Obtain a detailed understanding of - the development, activation, and differentiation of different types of T cells and their effector mechanisms during immune responses, - Recognition of pathogenic microorganisms by the host cells and molecular events thereafter, - events and factors for maturation of naive B cells to antibody producing plasma cells and memory B cells. - Optimization of B cell responses by intelligent design of new vaccines

Content
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the "Danger" concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at: https://moodle-app2.let.ethz.ch/course/view.php?id=2581

Prerequisites
Immunology I and II recommended but not compulsory

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>752-4009-00L</td>
<td>Molecular Biology of Foodborne Pathogens</td>
<td>W</td>
<td>3</td>
<td>2V</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<tr>
<td></td>
<td>Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.</td>
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<tr>
<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.</td>
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</table>

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Lecture notes
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

701-0263-01L Seminar in Evolutionary Ecology of Infectious Diseases

Abstract
Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

Objective
This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecological and evolutionary biology of infectious diseases.

Content
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

Module Nutrition and Health

<table>
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<tr>
<th>Course Code</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease</td>
<td>W</td>
<td>3</td>
<td>2V</td>
</tr>
<tr>
<td>Abstract</td>
<td>To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.</td>
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<td>Objective</td>
<td>To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of the complications of the chronic diseases.</td>
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<tr>
<td>Content</td>
<td>The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.</td>
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<tr>
<td>Lecture notes</td>
<td>There is no script. Powerpoint presentations will be made available on-line to students.</td>
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<tr>
<td>Literature</td>
<td>To be provided by the individual lecturers, at their discretion.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>No compulsory prerequisites, but prior completion of the courses &quot;Introduction to Nutritional Science&quot; and &quot;Advanced Topics in Nutritional Science&quot; is strongly advised.</td>
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</table>

752-2122-00L Food and Consumer Behaviour

Abstract
This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products.

Objective
The course provides an overview about the following topics: Factors influencing consumer's food choice, food and health, attitudes towards new foods and food technologies, labeling and food policy issues.

752-5103-00L Functional Microorganisms in Foods

Abstract
This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective
To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- **Probiotics and Prebiotics**: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

- **Protective Cultures and Antimicrobial Metabolites** for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.

- **Legal and protection issues related to functional foods**

- **Industrial biotechnology of flavor and taste development**

- **Safety of food cultures and probiotics**

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

**Lecture notes**
Copy of the power point slides from lectures will be provided.

**Literature**
A list of topics for group projects will be supplied, with key references for each topic.

**Prerequisites / notice**
This lecture requires strong basics in microbiology.
Content

This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of microorganisms with metabolic activities of high potential for application in food technology. Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation. Lectures are supplemented with handouts. Copies of slides from lectures will be provided.

Lecture notes

Copies of slides from lectures will be provided.

Literature

Electronic lecture handouts will be provided. The lectures will not be recorded. A list of learning materials will be provided online.

Prerequisites / notice

Students taking 752-5103-00L require a sound knowledge of basic chemistry, biochemistry, molecular genetics, microbiology and microbial physiology.

In order to decipher the costs of tastings, a financial participation of CHF20 will be required per student.

Fostered competencies

Some contents will be provided by registered students who will present as a group an actual publication.

752-5103-00L Functional Microorganisms in Foods

Abstract

This integration course will discuss new applications of functional microbes in food processing and products and in the human gut. Selected topics will be used to illustrate the rapid development but also limits of basic knowledge for applications of functional microorganisms to produce food with high quality and safety, and for health benefits for consumers.

Objective

To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Lecture notes

Copy of the power point slides from lectures will be provided.

Literature

A list of topics for group projects will be supplied, with key references for each topic.

This lecture requires strong basics in microbiology.

752-5111-00L Gene Technology in Foods

Abstract

This course will increase basic knowledge on biotechnological constructions and application of genetically modified organisms (GMO) which are used worldwide in food production systems. The course discusses health issues, the legislation frame and food safety aspects of GMO applications in agriculture, food production and consumption in Switzerland and EU-countries.

Objective

Criteria of rationale food safety and health assessment in agriculture and food consumption will be elaborated.

Content

- Safety of food cultures and probiotics
- Industrial biotechnology of flavor and taste development
- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Lecture notes

The lectures are supplemented with handouts.

Literature

Copies of slides from lectures will be provided.

Prerequisites / notice

Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.

752-5103-00L Functional Microorganisms in Foods

Number

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>752-1021-00L</td>
<td>Food Enzymology</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>L. Nyström, M. Erzinger</td>
</tr>
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</table>

Abstract

The course covers the fundamentals of food enzymology, application of endogenous and exogenous enzymes in food processing, as well as use of enzymes in analytics.

Objective

Students can describe what enzymes are and can explain their use and functions in food and food products. Students can argue why and how enzymes are used in food processing and analysis. Students execute a research project independently and defend their findings during a presentation to peer students and an expert panel.

Content

Enzymes in foods: the use of added enzymes in food processing, control and/or utilization of endogenous enzymes, production of enzyme preparations for food use, and chemical analysis of food components by enzymatic methods.

Lecture notes

The lectures are supplemented with handouts.
Course prerequisites: Food Chemistry I/II and Food Analysis I/II (or equivalent)

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

**Personal Competencies**
- Adaptability and Flexibility: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

**Modern Mass Spectrometry, Hyphenated Methods, and Chemometrics**
- W 6 credits 3G R. Zenobi, B. Hattendorf, M. Schmelcher, E. Wetter-Slack

**Abstract**
Modern mass spectrometry, hyphenated analytical methods, speciation, chemometrics.

**Objective**
Comprehensive knowledge about the analytical methods introduced in this course and their practical applications.

**Content**
Hyphenation of separation with identification methods such as GC-MS, LC-MS, GC-IR, LC-IR, LC-NMR etc.; importance of speciation. Modern mass spectrometry: time-of-flight, orbitrap and ion cyclotron resonance mass spectrometry, ICP-MS. Soft ionization methods, desorption methods, spray methods. Mass spectrometry imaging. Use of statistical and computer-assisted methods for processing analytical data (chemometrics).

**Lecture notes**
Lecture notes will be made available online.

**Literature**
Information about relevant literature will be available in the lecture & in the lecture notes.

**Prerequisites / notice**
Exercises are an integral part of the lecture. Prerequisites: 529-0051-00 "Analytische Chemie I (3. Semester)" 529-0058-00 "Analytische Chemie II (4. Semester)" (or equivalent)

## Food Microbiology

- **Number**: 752-4009-00L
- **Title**: Molecular Biology of Foodborne Pathogens
- **Type**: W+ 3 credits 2V
- **ECTS**: 3
- **Hours**: 2V
- **Lecturers**: M. Loessner, M. Schmelcher, M. Schuppler, E. Wetter Slack

**Abstract**
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

**Objective**
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

**Content**
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

**Lecture notes**
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

**Literature**
Recommendations will be given in the first lecture

**Prerequisites / notice**
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

- **Number**: 752-5103-00L
- **Title**: Functional Microorganisms in Foods
- **Type**: W 3 credits 2G
- **ECTS**: 3
- **Hours**: 2G
- **Lecturers**: C. Lacroix, A. Geimaert, A. Greppi
This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

### Food Process Design

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
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<tr>
<td>752-3021-00L</td>
<td>Food Process Design and Optimization</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>E. J. Windhab</td>
</tr>
<tr>
<td>Objective</td>
<td>Quantitative process analysis and derivation of process-structure functions for complex liquid or semi-liquid food systems with non-Newtonian flow properties. Handling of optimisation and up-/down-scaling procedures.</td>
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<tr>
<td>Content</td>
<td>S-PRO2 scheme, reverse engineering approach, dimension analysis, Metzner-Otto and Rieger Novack design schemes of stirred reactors for non-Newtonian fluid processing, mixing/mixing statistics, mixing characteristics, power charac-teristics, dispersing characteristics, dispersing processes in rotor/ stator and membrane devices, spray processing, extrusion processing, diverse case studies for design and scaling of processes for food structure processing</td>
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<tr>
<td>Lecture notes</td>
<td>Printed handouts (ca. 180)</td>
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<tr>
<td>Literature</td>
<td>List of ca. 30 papers and 5 books given in course</td>
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<tr>
<td>752-3023-00L</td>
<td>Process Measurements and Automation</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>E. J. Windhab</td>
</tr>
<tr>
<td>Abstract</td>
<td>Overview on Process Automation, Information Management in processes, process data handling and analysis, In-line measurements of complex food systems, Process control schemes, Overview of sensors and sensor principles, integrated process control case studies</td>
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<tr>
<td>Objective</td>
<td>Understanding the interplay of in-line measurements of complex food properties in processes, process data handling and data analysis as well as building blocks for process control.</td>
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<tr>
<td>Content</td>
<td>Overview Process Automation, Process Control and process data management, Industrial design of automated/controlled processes, overview on sensors/sensor principles, case studies of in-line measurements and control in/of food production processes</td>
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<tr>
<td>Lecture notes</td>
<td>Printed script (120 pages, 80 figures), diverse publications</td>
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<tr>
<td>Literature</td>
<td>List of publications and books given in course</td>
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### Food Sensory Science and Consumer Behaviour

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<th>Hours</th>
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<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
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<tr>
<td>Abstract</td>
<td>This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products. The course provides an overview about the following topics: Factors influencing consumer's food choice, food and health, attitudes towards new foods and food technologies, labeling and food policy issues</td>
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<tr>
<td>Literature</td>
<td>To be provided by the individual lecturers, at their discretion.</td>
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### Public Nutrition and Health

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<tbody>
<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. B. Zimmerman</td>
</tr>
<tr>
<td>Abstract</td>
<td>To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.</td>
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<td>Objective</td>
<td>To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic disease, as well as the progression of complications of the chronic diseases.</td>
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<td>Content</td>
<td>The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.</td>
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<td>Lecture notes</td>
<td>There is no script. Powerpoint presentations will be made available on-line to students.</td>
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<tr>
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<td>To be provided by the individual lecturers, at their discretion.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>No compulsory prerequisites, but prior completion of the courses &quot;Introduction to Nutritional Science&quot; and &quot;Advanced Topics in Nutritional Science&quot; is strongly advised.</td>
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<tr>
<td>752-6105-00L</td>
<td>Epidemiology and Prevention</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>M. Puhan, R. Heusser</td>
</tr>
<tr>
<td>Abstract</td>
<td>The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1397 of 2416
Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Fostered competencies
Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies
Decision-making
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking

Safely and Quality in Agri-Food Chain

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</thead>
<tbody>
<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
</tr>
<tr>
<td>752-2307-00L</td>
<td>Nutritional Aspects of Food Composition and Processing</td>
<td>W*</td>
<td>3</td>
<td>2V</td>
<td>B. E. Baumer, J. M. Sych</td>
</tr>
<tr>
<td>751-6001-00L</td>
<td>Forum: Livestock in the World Food System</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>S. Meese</td>
</tr>
<tr>
<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>F. Constancias, G. Broggini, S. Bull, A. Greppi, F. Orelli</td>
</tr>
</tbody>
</table>

Abstract
This course focuses on food consumer behavior, consumer's decision-making processes and consumer's attitudes towards food products.

Objective
The course provides an overview about the following topics: Factors influencing consumer's food choice, food and health, attitudes towards new foods and food technologies, labeling and food policy issues.

Abstract
Lecture type course with an interdisciplinary approach for the evaluation of nutritional aspects of changes in food composition due to processing.

Objective
Students should be able to
- describe and compare the major concepts /criteria used for the evaluation of the nutritional quality of food
- apply these criteria when assessing the effects of selected processing technologies on nutritional quality.
- evaluate recent formulation strategies aimed to achieve additional physiological benefits for targeted population groups (i.e. functional foods).

Content
The course gives inputs on compositional changes in food due to processing (with focus on thermal/chilling, enzymatic, chemical, emerging technologies) or new formulation strategies. New approaches for evaluating these changes (e.g. nutritional profiles) and how these are communicated to consumers are also discussed.

Lecture notes
There is no script. Powerpoint presentations and relevant scientific articles will be available on-line for students. A selection of recommended readings will be given at the beginning of the course.

Prerequisites / notice
The course is open to Master and MAS students in food and science and nutrition or related. Basic knowledge of food chemistry and nutrition is expected, as well as an understanding of food processing.

Abstract
This course will increase basic knowledge on biotechnological constructions and application of genetically modified organisms (GMO) which are used worldwide in food production systems. The course discusses health issues, the legislation frame and food safety aspects of GMO applications in agriculture, food production and consumption in Switzerland and EU-countries.
At the end of this course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive ECTS provided in the lecture notes.

P. A. Fischer

The journal-club style course involves student presentations and active discussion of recent publications. The primary focus is on 2V W+ to stimulate student interest and provide advanced knowledge of Type, F. Michailidou

Physics of Food Colloids

Journal-club style course involving student presentations and active discussion of recent publications and modern experimental strategies. The focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester.

K. Hecht, F. Michailidou

For Masters level participants, a strict prerequisite is (a) previously taken and passed “Introduction to Toxicology” (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take "Special Topics in Toxicology", do not register at the same time for “Advanced Topics in Toxicology”. It is only possible to take one, and it is only possible to take the advanced level after completing this course.

752-1302-00L Advanced Topics in Toxicology W 2 credits 2G F. Michailidou, S. J. Sturia

Copies of slides from lectures will be provided

Actual publications from literature will be provided

Good knowledge in biology, especially in microbiology and molecular biology are prerequisites.

Some contents will be provided by registered students who will present as a group an actual publication.

751-7310-00L Bioactive Food and Feed Components W 2 credits 2V K. Giller

The course provides students with the basic knowledge to understand the connection between the structure of nutritive and non-nutritive bioactive food and feed components and their effects on the nutrient supply and health of humans and livestock as well as on the quality of animal-derived foods.

At the end of the course, the students are aware of food and feed as sources of different bioactive compounds. By a comprehensive understanding of the connection between bioavailability, molecular mechanisms and biological effects, they are able to apply their knowledge on beneficial and detrimental effects of bioactive food and feed components in the fields of human and animal nutrition.

Topics include:
- sources of bioactive food and feed components
- bioavailability and modification in the gastrointestinal tract
- beneficial and detrimental effects
- molecular mechanisms of biological effects
- species differences concerning metabolism and biological effects

The course gives an introduction into different classes of bioactive components present in food and feed including fatty acids and secondary plant compounds such as carotenoids, polyphenols, phytoestrogens, glucosinolates, protease inhibitors and monoterpenes.

The teaching slides and other materials will be provided during the course.

Information about books and other references will be communicated during the course.

752-3103-00L Food Rheology I

Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.

The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

752-2314-00L Physics of Food Colloids

In Physics of Food Colloids the principles of colloid science will applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

The aggregation of food material determines the appearance and performance of complex food system as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure exiting food or to design new products. The application and use of these concepts are discussed in light of common food production.

Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h). Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigation complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

752-1301-00L Special Topics in Toxicology

Journal-club style course involving student presentations and active discussion of recent publications and modern experimental strategies. The focus is on chemical, biochemical, and nutritional aspects of selected topics in Toxicology, with a new group of topics addressed each semester.

Lectures involve student presentations and active discussion of recent publications. The primary focus is on chemical, biochemical, and nutritional aspects of selected current topics in Toxicology. Participants are masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Biochemistry, Pharmaceutical Sciences, etc.).

A selection of approximately 20 papers from recent primary scientific literature.

For Masters level participants, a strict prerequisite is (a) previously taken and passed “Introduction to Toxicology” (752-1300) and/or (b) previous courses supporting equivalent knowledge plus permission from the instructor. Please contact the instructor before the start of the class, explaining the basis of your previous knowledge other than the Introduction course, to request special permission.

If you would like to take “Special Topics in Toxicology”, do not register at the same time for “Advanced Topics in Toxicology”. It is only possible to take one, and it is only possible to take the advanced level after completing this course.
Abstract
Journal-club style course that involves student presentations of selected topics in Toxicology on the basis of current primary research and review papers.

Objective
The goals are to stimulate student interest and provide advanced knowledge of current research in the interdisciplinary area of Food and Nutrition Toxicology and its related sciences. The student should develop skills in the critical evaluation of scientific literature, oral presentation and questioning, and understanding modern experimental techniques in Molecular Toxicology.

Content
The journal-club style course involves student presentations of recent publications. The primary focus is on chemical and biochemical aspects of selected topics in Toxicology. Participants are generally masters or PhD students in Food Sciences and related disciplines (i.e. Chemistry, Pharmaceutical Sciences, etc.), and strong knowledge of organic chemistry and biochemistry are prerequisite. Selected course topics change every semester.

Prerequisites / notice
Participants are required to have completed previously “Special Topics in Toxicology” (752-1301-00L). Both courses are run concurrently every semester. It is only possible to register for one course at a time. Do not register for “Advanced Topics in Toxicology” until after you have completed “Special Topics in Toxicology”

752-4009-00L Molecular Biology of Foodborne Pathogens W 3 credits 2V M. Loesener, M. Schmelcher, M. Schuppler, E. Wetter Slack

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as as the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes Literature
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

752-6105-00L Epidemiology and Prevention W 3 credits 2V M. Puhar, R. Heusser

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective
The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes Literature
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

376-1353-00L Nanostructured Materials Safety W 2 credits 1V P. Wick

Abstract
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

Objective
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

Lecture notes Literature
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

Prerequisites / notice
Course “Introduction to Toxicology”

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed
Project Management not assessed
Social Competencies
Communication not assessed
Personal Competencies
Creative Thinking not assessed

Cooperation and Teamwork not assessed

Critical Thinking assessed

333-1193-00L Electives

Number Title Type ECTS Hours Lecturers
752-0005-00L Colloquium in Food and Nutrition Science W 1 credit 2K S. J. Sturla

Abstract
Participation in weekly seminars on a variety of topics including Food Microbiology, Food Toxicology, Food Biochemistry, Food Processing, Consumer Behavior, Food Technology, and Food Materials and Technology, and oral presentation of a selected published study in one of these areas inspired by participation in the seminars.

Objective
The objectives are to become familiar with and stimulate interest in leading-edge science related to the research topics of the Institute of Food, Nutrition and Health. Participants attend weekly seminars given by external and internal speakers, and are also required to deliver a presentation on a recent research article inspired by a topic from the semester presentations.
### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-0230-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Supervisors</td>
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</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme;
- c. has acquired at least 30 CPs in the master programme.

The topic of the thesis and - if they are not Professors of D-HEST - the examiner and the co-examiner have to be approved by the D-HEST Department Conference.

**Abstract**

The Master thesis completes the master programme and is an independent scientific project. Generally, the topic is selected from the specific field of the major. It is supervised by a professor/Privatdozenten at D-HEST or D-USYS, Agricultural Sciences.

**Objective**

The Master Thesis must demonstrate the student's ability to independent, structured and scientific working.

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tbody>
<tr>
<td>752-1000-AAL</td>
<td>Food Chemistry I</td>
<td>E</td>
<td>3</td>
<td>6R</td>
<td>L. Nyström</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

To familiarise with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

**Objective**

To familiarise with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

**Content**

Descriptive chemistry of food constituents (proteins, lipids, carbohydrates, plant phenolics, flavour compounds).

Reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (e.g. lipid oxidation, Maillard reaction, enzymatic browning).

Links to food analysis, food processing, and nutrition.

**Lecture notes**

The lectures are supplemented with handouts.

**Literature**


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-1101-AAL</td>
<td>Food Analysis I</td>
<td>E</td>
<td>3</td>
<td>6R</td>
<td>L. Nyström</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

To understand the basic principles of analytical chemistry. To get acquainted with the principles and applications of important routine methods of instrumental food analysis (UV/VIS, IR, AAS, GC, HPLC).

**Objective**

To understand the basic principles of analytical chemistry. To get acquainted with the principles and applications of important routine methods of instrumental food analysis (UV/VIS, IR, AAS, GC, HPLC).

**Content**


Methods: Optical spectroscopy (basic principles, UV/VIS, IR, and atomic absorption spectroscopy), Chromatography (GC, HPLC).

**Lecture notes**

The lectures are supplemented with handouts.

**Literature**


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>752-3000-AAL</td>
<td>Food Process Engineering I</td>
<td>E</td>
<td>4</td>
<td>9R</td>
<td>P. A. Fischer</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

To procure students with the basic physics of food process engineering, especially with the mechanical futures of food systems, i.e. basic principles of engineering mechanics, of thermodynamics, fluid dynamics and of dimension analyses for process design and Non-Newtonian fluid mechanics.

**Objective**


**Content**


**Literature**


<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>752-6001-AAL</td>
<td>Introduction to Nutritional Science</td>
<td>E</td>
<td>3</td>
<td>6R</td>
<td>M. B. Zimmermann, C. Wolfrum</td>
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</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

**Objective**

To introduce the students to the both macro- and micronutrients in relation to food and metabolism.
### General Biology I

**Enrolment** ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

**Abstract**
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

**Objective**
The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

**Content**

- Week 1-7 by Alex Widmer, Chapters 12-25
  - 12 Cell biology Mitosis
  - 13 Genetics Sexual life cycles and meiosis
  - 14 Genetics Mendelian genetics
  - 15 Genetics Linkage and chromosomes
  - 20 Genetics Evolution of genomes
  - 21 Evolution How evolution works
  - 22 Evolution Phylogenetic reconstructions
  - 23 Evolution Microevolution
  - 24 Evolution Species and speciation
  - 25 Evolution Macroevolution

- Week 8-14 by Oliver Martin, Chapters 26-34
  - 26 Diversity of Life Introduction to viruses
  - 27 Diversity of Life Prokaryotes
  - 28 Diversity of Life Origin & evolution of eukaryotes
  - 29 Diversity of Life Nonvascular&seedless vascular plants
  - 30 Diversity of Life Seed plants
  - 31 Diversity of Life Introduction to fungi
  - 32 Diversity of Life Overview of animal diversity
  - 33 Diversity of Life Introduction to invertebrates
  - 34 Diversity of Life Origin & evolution of vertebrates

**Lecture notes** No script

**Literature**

### Physics II

**Enrolment** ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

**Abstract**
Introduction to the "way of thinking" and the methodology in Physics. The Chapters treated are Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

**Objective**
The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

**Content**

- **Book**
  - Chapters:

- **Literature**
  - Friedhelm Kuppers
  - Physik für Ingenieure und Naturwissenschaftler
  - Band 2 Elektrizität, Optik, Wellen
  - Verlag Wiley-VCH, 2003, Fr. 77.-

### Stochastics (Probability and Statistics)

**Enrolment** ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

**Abstract**
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

**Objective**
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language “R.”
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed

Personal Competencies
Self-direction and Self-management assessed

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<tr>
<td>752-4001-AAL</td>
<td>Microbiology</td>
<td>2 credits</td>
<td>E-</td>
<td>4R</td>
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<tr>
<td>701-0071-AAL</td>
<td>Mathematics III: Systems Analysis</td>
<td>4 credits</td>
<td>E-</td>
<td>9R</td>
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<tr>
<td>752-4005-AAL</td>
<td>Food Microbiology I</td>
<td>3 credits</td>
<td>E-</td>
<td>6R</td>
</tr>
</tbody>
</table>

Abstract
Self-study course in microbiology.

Objective
Teaching of basic knowledge in microbiology.

Content
This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature
This self-study course is based on the book 'Brock, Biology of Microorganisms'.

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content
Introduction to principles of models; one-dimensional linear box models; multi-dimensional linear box models; nonlinear box models; models in space and time.

Lecture notes
Teaching material: book (see literature).

Literature

Content
1. History of Food Microbiology
   1.1. Short synopsis of foodborne microorganisms
   1.2. Spoilage of Foods
   1.3. Foodborne Disease
   1.4. Food Preservation
   1.5. VIP's of Food Microbiology
2. Overview of Microorganisms in Foods
   2.1 Origin of foodborne Microorganisms
   2.2. Bacteria
   2.3. Yeasts
   2.4. Molds
3. Microbial Spoilage of Foods
   3.1. Intrinsic and Extrinsic Parameters
   3.2. Meats, Seafoods, Eggs
   3.3. Milk and Milk Products
   3.4. Vegetable and Fruit Products
   3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
   3.6. Drinks and Canned Foods
4. Foodborne Disease
   4.1. Significance and Transmission of Foodborne pathogens
   4.2. Staphylococcus aureus
   4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
   4.4. Listeria monocytogenes
   4.5. Salmonella, Shigella, Escherichia coli
   4.6. Vibrio, Yersinia, Campylobacter
   4.7. Brucella, Mycobacterium
   4.8. Parasites
   4.9. Viruses and Bacteriophages
   4.10. Mycotoxins
   4.11. Bioactive Amines
   4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

551-0003-AAL General Biology I+II E- 7 credits 13R U. Sauer, K. Bomblies, O. Y. Martin, A. Widmer

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Biology I: Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

General Biology II: Molecular biology approach to teach the basic principles of biochemistry, cell biology, cgenetics, evolutionary biology and form and function of vascular plants.

Objective
General Biology I: The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

General Biology II: The understanding basic concepts of biology: the hierarchy of the structural levels of biological organisation, with particular emphasis on the cell and its molecular functions, the fundamentals of metabolism and molecular genetics, as well as form and function of vascular plants.
General Biology I:
General Biology I focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogenetic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular&seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

General Biology II: The structure and function of biomacromolecules; basics of metabolism; tour of the cell; membrane structure and function; basic energetics of cellular processes; respiration, photosynthesis; cell cycle, from gene to protein; structure and growth of vascular plants, resource acquisition and transport, soil and plant nutrition.

Specifically the following Campbell chapters will be covered:
3 Biochemistry Chemistry of water
4 Biochemistry Carbon: the basis of molecular diversity
5 Biochemistry Biological macromolecules and lipids
7 Cell biology Cell structure and function
8 Cell biology Cell membranes
10 Cell biology Respiration: introduction to metabolism
10 Cell biology Cell respiration
11 Cell biology Photosynthetic processes
16 Genetics Nucleic acids and inheritance
17 Genetics Expression of genes
18 Genetics Control of gene expression
19 Genetics DNA Technology
35 Plant structure&function Plant Structure and Growth
36 Plant structure&function Transport in vascular plants
37 Plant structure&function Plant nutrition
38 Plant structure&function Reproduction of flowering plants
39 Plant structure&function Plants signal and behavior

This is a virtual self-study lecture for non-German speakers of the "Allgemeine Biology I (551-0001-00L) and "Allgemeine Biology II (551-0002-00L) lectures. The exam will be written jointly with the participants of this lecture.

752-0100-AAL
Biochemistry 2 credits 4R C. Frei
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.
Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

Objective
Based on the biology and chemistry courses in the 1. and 2. semester more detailed biochemical knowledge about enzymology, membrane biochemistry, and central metabolism will be presented

Content
Program
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Carbohydrates, structure of DNA
Lipids and biological membranes
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis
The citric acid cycle
Oxidative phosphorylation
Fatty acid metabolism

Lecture notes
by Laurence A. Moran (Author), Robert A Horton (Author), Gray Scrimgeour (Author), Marc Perry (Author)

Literature
by Laurence A. Moran (Author), Robert A Horton (Author), Gray Scrimgeour (Author), Marc Perry (Author)

Prerequisites / notice
Basic knowledge in biology and chemistry is a precondition.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

Techniques and Technologies
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Analytical Competencies
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

752-6306-AAL Physiology and Anatomy II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Imparts a basic understanding of physiology and anatomy in man, focusing on the close interrelations between morphology and function of the human organism. This is fostered by discussing all subjects from a functional point of view. A major topic of the lecture is food intake and digestion with its correlated endocrine and metabolic processes.

Objective
After this course the students are able to understand basic principles of systems physiology and the mechanisms of the function of the major organ systems.

752-2120-AAL Consumer Behaviour I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Objective
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Food Science Master - Key for Type

| Q | Compulsory | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W | Eligible for credits | Dr | Suitable for doctorate |

Key for Hours

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
# Food Science Bachelor

## 1. Semester

### First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-2001-02L</td>
<td>Chemistry I</td>
<td>O</td>
<td>4</td>
<td>2V+2U</td>
<td>J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel</td>
</tr>
</tbody>
</table>

**Abstract**

General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course "Chemistry I", the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

**Objective**

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

**Content**

1. Stoichiometry
   - Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
4. Basics of chemical thermodynamics
5. System and surroundings. Description of state and change of state of chemical systems.
6. First law of thermodynamics
7. Second law of thermodynamics
   - Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
8. Gibbs energy and chemical potential.
9. Chemical equilibrium
10. Acids and bases
11. Dissolution and precipitation.
    - Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

**Lecture notes**

Online-Skript mit durchgerechneten Beispielen.

**Literature**


Weiterführende Literatur:


**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<td></td>
<td>Customer Orientation</td>
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<td></td>
<td>Leadership and Responsibility</td>
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<td></td>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
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<tr>
<td></td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

| 401-0251-00L | Mathematics I | O | 6 credits | 4V+2U | A. Cannas da Silva |

**Abstract**

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

**Objective**

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.
The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research.

1. Single-Variable Calculus:
   - review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

2. Linear Algebra and Complex Numbers:
   - systems of linear equations, Gaussian-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

3. Ordinary Differential Equations:
   - separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

Literature
- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

Prerequisites
Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Hours</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0001-00L</td>
<td>General Biology I</td>
<td>3</td>
<td>3V</td>
<td>U. Sauer, O. Y. Martin, A. Widmer</td>
</tr>
<tr>
<td>701-0243-01L</td>
<td>Essentials of Ecology</td>
<td>2</td>
<td>2V</td>
<td>C. Buser Moser</td>
</tr>
<tr>
<td>701-0027-00L</td>
<td>Environmental Systems I</td>
<td>2</td>
<td>2V</td>
<td>C. Schär, N. Dubois, G. Velicer</td>
</tr>
</tbody>
</table>

**Objective**
The understanding of some basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

**Content**
- Week 1-7 by Alex Widmer, Chapters 12-25
  - Cell biology
  - Mitosis
  - Genetics
  - Sexual life cycles and meiosis
  - Genetics
  - Mendelian genetics
  - Genetics
  - Linkage and chromosomes
  - Genetics
  - Evolution of genomes
  - Evolution
  - How evolution works
  - Evolution
  - Phylogenetic reconstructions
  - Evolution
  - Microevolution
  - Evolution
  - Species and speciation
  - Evolution
  - Macroevolution
- Week 8-14 by Oliver Martin, Chapters 26-34
  - Diversity of Life
  - Introduction to viruses
  - Diversity of Life
  - Prokaryotes
  - Diversity of Life
  - Origin & evolution of eukaryotes
  - Diversity of Life
  - Nonvascular/seedless vascular plants
  - Diversity of Life
  - Seed plants
  - Diversity of Life
  - Introduction to fungi
  - Diversity of Life
  - Overview of animal diversity
  - Diversity of Life
  - Introduction to invertebrates
  - Diversity of Life
  - Origin & evolution of vertebrates

**Lecture notes**
- no script

**Literature**

**Prerequisites**
The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.
The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of raw materials and fossil fuels, climate change and its impacts on man and environment, and the spread and control of infectious diseases in the human population and agricultural systems.

Lecture notes
Slides are provided by instructors and are accessible via moodle.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0839-00L</td>
<td>Informatics</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>L. E. Fässler, M. Dahinden</td>
</tr>
</tbody>
</table>

Additional First Year Courses

New to the first year courses, the following concepts will be introduced:
- handle the complexity of real-world data.
- process and analyze real-world data from their subject of study,
- choose and apply appropriate tools from computer science,
- handle the complexity of real-world data.

The students will especially comprehend the following concepts in the new courses:
- Evaluate economic measures.
- Introduce economic reasoning appropriately to a given topic.
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Analytical Competencies: Concepts and Theories assessed
- Decision-making assessed
- Problem-solving assessed
- Critical Thinking evaluated
- Self-direction and Self-management assessed

The course shall particularly elucidate the cross section of Agro- and Food Sciences in the context of important global problems to be solved. Furthermore, the students shall particularly elucidate the cross section of Agro- and Food Sciences in the context of important global problems to be solved. In doing so, important corresponding aspects for developed, emerging and developing countries are demonstrated, by use of engineering as well as natural and social science approaches.

The course is part of the block exam after the first study year. Paper copies can be used ("Open Book") during the on-line exam, but no other means are allowed. The course is mainly taught in German, single might be in English.
This course is intended to provide an overview of experimental chemical methods. Principles and methods of light microscopy. Preparation of specimen for microscopy; documentation. Anatomy of seed plants: From cells to organs. Special features of plant cells. Anatomy and function of plant organs. Anatomical adaptations to different environments.

### 751-0801-00L Fundamentals of Microscopy and Plant Biology

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1V+2G</td>
<td>E. B. Truernit</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Capability of preparing biological specimen, microscopy and documentation. Understanding the correlation between plant structure and function at the level of organs, tissues and cells.

**Content**

**Lecture notes**
Handouts

**Literature**
For further reading (not obligatory):
Gerhard Wanner: Mikroskopisch-Botanisches Praktikum, Georg Thieme Verlag, Stuttgart.

**Prerequisites**
Groups of a maximum of 30 students.

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### 529-0030-00L Laboratory Course: Elementary Chemical Techniques

<table>
<thead>
<tr>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>6P</td>
<td>A. de Mello, F. Jenny, M. H. Schroth</td>
</tr>
</tbody>
</table>

**Abstract**
This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g. investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

**Objective**
The handling of chemicals and proper laboratory techniques represent the main learning targets. Furthermore, the description and recording of laboratory processes is an essential part of this course.

**Content**
The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytic and synthetic tasks: Selected samples (e.g. soil and water) will be analysed with various methods, such as titrations, spectrophotometry or ion chromatography. The chemistry of aqueous solutions (acid-base equilibria and solvation or precipitation processes) is studied. The synthesis of simple inorganic complexes or organic molecules is practised. Furthermore, the preparation and handling of environmentally relevant gaseous species like carbon dioxide or nitrogen oxides is a central subject of the Praktikum.

**Lecture notes**
The script will be published on the web. Details will be provided on the first day of the semester.

**Literature**
A thorough study of all script materials is requested before the course starts.

**Prerequisites**
Safety conceptt: https://chab.ethz.ch/studium/bachelor1.html

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### 3. Semester

#### Basic Courses II

#### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>402-0063-00L</td>
<td>Physics II</td>
<td>O</td>
<td>5</td>
<td>3V+1U</td>
<td>A. Vaterlaus</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction to the concepts and tools in Physics, with the help of demonstration experiments. The Chapters treated are Electromagnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena. Whenever possible, examples relevant to the students’ main field of study are given.

**Objective**
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.

**Lecture notes**
A script will be distributed
Literature
Friedhelm Kuypers
Physik für Ingenieure und Naturwissenschaftler
Band 2 Elektrizität, Optik, Wellen
Wiley-VCH, 2012
ISBN 3527411445, 9783527411443

Douglas C. Giancoli
Physik
3. erweiterte Auflage
Pearson Studium

Hans J. Paus
Physik in Experimenten und Beispielen
Carl Hanser Verlag, München, 2002, 1068 S.

Paul A. Tipler
Physik
Spektrum Akademischer Verlag, 1998, 1522 S., ca Fr. 120.-

David Halliday Robert Resnick Jearl Walker
Physik
Wiley-VCH, 2003, 1388 S., Fr. 87.- (bis 31.12.03)
dazu gratis Online Ressourcen (z.B. Simulationen): www.halliday.de

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies not assessed
Decision-making not assessed
Problem-solving assessed

Social Competencies
Communication not assessed

701-0071-00L Mathematics III: Systems Analysis O 4 credits 2V+1U C. Brunner, R. Knutti, S. Schemm, H. Wernli

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content
https://iac.ethz.ch/edu/courses/bachelor/vorbereitung/systemanalyse.html
Lecture notes
Overhead slides will be made available through the course website.

Literature

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Personal Competencies
Creative Thinking not assessed
Critical Thinking not assessed

752-4001-00L Microbiology O 2 credits 2V M. Ackermann, M. Schuppler, J. Vorholt-Zambelli

Abstract
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

Objective
Teaching of basic knowledge in microbiology.

Content

Lecture notes
Wird von den jeweiligen Dozenten ausgegeben.

Literature
Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

752-0100-00L Biochemistry O 2 credits 2V C. Frei

Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo. Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

Objective
Students are able to understand
- the structure and function of biological macromolecules
- the kinetic bases of enzyme reactions
- thermodynamic and mechanistic basics of relevant metabolic processes
Students are able to describe the relevant metabolic reactions in detail

Content
Program
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Carbohydrates
Lipids an biological membranes
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis, fermentation
The citric acid cycle
Oxidative phosphorylation
Fatty acid metabolism

Lecture notes
Horton et al. (Pearson) serves as lecture notes.
Prerequisites / Fostered competencies
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**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

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**752-6305-00L Physiology and Anatomy I**

**Type**: O | **ECTS**: 2 | **Hours**: 2V | **Lecturers**: D. Burdakov, D. Peleg-Raibstein

**Abstract**
Imparts a basic understanding of physiology and anatomy, focusing on the interrelations between morphology and function of the human organism. This is fostered by discussing all subjects from a functional point of view. One major topic of the lecture is food intake, food taste, and digestion with its correlated neural, endocrine and metabolic processes.

**Objective**
At the end of the course the students understand the basic functions of the organ systems and functionally important morphological features. One focus of the course is on aspects related to nutrition and overweight including the resulting diseases.

---

**701-0225-00L Organic Chemistry**

**Type**: O | **ECTS**: 2 | **Hours**: 2V+1U | **Lecturers**: K. McNeill

**Abstract**
Basics of Organic Chemistry.

**Objective**
This course builds on General Chemistry I and II.

The students will learn the basic reaction mechanisms in organic chemistry. They will be able to understand and formulate simple organic reactions.

**Content**
Descriptive chemistry of functional groups (alkyl halides, alkenes, aromatic systems, carbonyls).

**Literature**
Carsten Schmuck, Basisbuch Organische Chemie, Pearson

---

**401-0624-00L Mathematics IV: Statistics**

**Type**: O | **ECTS**: 4 | **Hours**: 2V+1U | **Lecturers**: J. Ernst

**Abstract**
Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

**Objective**
Capacity to learn from data; good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.

**Content**
Descriptive statistics and probability theory (e.g., mean values, standard deviation, etc.).

**Literature**

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**752-0180-00L Principles in Food Science**

**Type**: O | **ECTS**: 3 | **Hours**: 2V | **Lecturers**: S. J. Sturla, M. Arnoldini, A. Delbrück, P. A. Fischer, E. Wetter Slack

**Abstract**
What is Food Science? The course will introduce students to the biological, physical and engineering basis of food and its role for society. It will center around 3 case examples in which students will be introduced to basic concepts integrating several key disciplines of food science. Each example will be comprised of significant active learning content and practice in scientific communication.

**Objective**
1. Gain an introductory knowledge of the multi-disciplinary topics comprising Food Science.
2. Understand how the multiple disciplines of food science interrelate in an applied context via guided learning of selected examples of foods and human health.
3. Be prepared to make informed decisions about future steps in the food science education and career.
4. Be able to write a well-structured paragraph

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**402-0000-02L Laboratory Course in Physics for Students in Food**

**Type**: O | **ECTS**: 2 | **Hours**: 4P | **Lecturers**: A. Biland, A. Eggenberger, A. Müller
Only students from 3rd Semester BSc Food Science on are admitted to this Laboratory Course.

**Abstract**
The central aim is to provide an individual experience of the physical phenomena and the basic principles of the experiment. By conducting simple physical experiments the student will learn how to properly use physical instruments and how to evaluate the results correctly.

**Objective**
This laboratory course aims to provide basic knowledge of - the setup of a physics experiment, - the use of measurement instruments, - various measuring techniques, - the analysis or measurement errors, - and the interpretation of the measured quantities.

**Content**
Sicherheit im Praktikum; Fehlerrechnung und Berichte verfassen; 6 ausgewählte Versuche zu unterschiedlichen Themen. Die Auswahl der Versuche kann zwischen den einzelnen Studiengängen variieren.

**Lecture notes**
Anleitungen zum Physikalischen Praktikum

### 752-4003-00L Practical Course in Microbiology

**Abstract**
Basic principles of the handling of microorganisms (MO) - Detection of MO in the environment - Morphology and diagnostics of MO - Morphology and physiology of fungi - Antimicrobial agents - Microbial genetics - Bacterial physiology and interactions - Microbial pest control

**Objective**
The students are familiar with the laboratory work with microorganisms. Specific emphasis is put on the isolation and maintenance of pure cultures and the required hygiene measures. The students know the clinical and ecological importance of microorganisms.

**Content**
In an introductory part students are made familiar with the handling and cultivation of microorganisms (MO). Afterwards, the students detect MO in the environment and use MO for the conservation of food. This part is then followed by a practical introduction on routine diagnostics of MO and experiments with antimicrobial agents. On simple experiments, the students experience the interaction of MO with higher organisms - the common topic of all research groups at the Institute of MO. Simple experiments demonstrate the importance of MO in molecular genetics. The course ends with a short introduction into the fungi and an example of applied microbiology i.e., an experiment on microbial pest control.

**Lecture notes**
A detailed script of approx. 100 pp. and other relevant documents are available at Moodle at latest 1 week before the beginning of the practical course.

**Literature**
Recommended literature (facultative):
- Allgemeine Mikrobiologie by Georg Fuchs and Hans G. Schlegel, Thieme-Verlag, 9. Auflage 2014
- Taschenlehrbuch Biologie: Mikrobiologie by Katharina Munk, Thieme Verlag, 2008

**Prerequisites / notice**
Performance of the students in this practical course is controlled by:
1. Attendance of all 7 course days
2. Handing in of written reports to selected experiments (in groups of 2 students)
3. Preparation of a poster to a selected topic of Microbiology (in groups of 4 students)

Participating doctoral students who collect credit points during their thesis are examined in a 30-minute oral exam at the end of the course.

### Basics of Food Science

#### Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
752-1000-00L | Food Chemistry I | W+ | 3 credits | 2V | L. Nyström, S. Boulos, M. Erzinger

**Abstract**
To familiarise with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

**Objective**
Recognize chemical structures of the main ingredients and be able to draw them themselves
Being able to recognize functional groups and assess their properties
Understand chemical reactions and be able to estimate their influence on the quality of a food product
Being able to explain the Maillard reaction and lipid oxidation

**Content**
Descriptive chemistry of food constituents (proteins, lipids, carbohydrates, plant phenolics, flavour compounds), reactions which affect the colour, flavour, texture, and the nutritional value of food raw materials and food products during processing, storage and preparation in a positive or in a negative way (e.g. lipid oxidation, Maillard reaction, enzymatic browning).
Links to food analysis, food processing, and nutrition.

**Lecture notes**
The lectures are supplemented with handouts.

**Literature**

**Fostered competencies**
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: not assessed
- Problem-solving: not assessed

### Basics of Food Science

#### 752-5001-00L Food Biotechnology

**Number | Title | Type | ECTS | Hours | Lecturers
---|---|---|---|---|---
752-5001-00L | Food Biotechnology | W | 4 credits | 3V | C. Lacroix, F. Constancias, B. Pugin
Biotechnology has been defined as any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses. In this course, basic knowledge for understanding biotechnology as applied to food processing will be presented. This course builds on the application of principles learned from other basic courses in the Bachelor program, especially microbiology and microbial metabolism, molecular biology, biochemistry, physics and engineering. Students will learn about the physiology of important productive microorganisms (lactic acid bacteria, bifidobacteria, propionibacteria and fungi) used in food fermentations, closely related to applications in biotechnology. Microbial and fermentation kinetics, and design and operation of fermentations and bioreactors used for both research and industrial scale production of traditional foods and modern food ingredients will be presented. This part will be illustrated by examples of food fermentation processes, representative of specific challenges. Finally, the application of modern molecular tools to food biotechnology will be discussed.

Lecture notes
A copy of the power point slides from each lecture will be provided.

Literature
A list of references will be given at the beginning of the course for the different topics presented during the course.

752-6001-00L Introduction to Nutritional Science W 3 credits 2V M. B. Zimmermann, C. Wolfrum

Abstract
This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

Objective
To introduce the students to the both macro- and micronutrients in relation to food and metabolism.

Content
The course is divided into two parts. The lectures on micronutrients are given by Prof. Zimmermann and the lectures on macronutrients are given by Prof. Wolfrum. Prof. Zimmermann discusses the micronutrients, including fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. Prof. Wolfrum introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeorhesis are emphasized.

Lecture notes
There is no script. Powerpoint presentations will be made available.

Literature


752-4005-00L Food Microbiology I W 3 credits 2V M. Loessner

Abstract
This lecture is the first part of a one-year course. It offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts and molds present in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms.

Objective
The lecture offers insights into the fundamentals and applications of Food Microbiology. Contents include basic microbiology of the different bacteria, yeasts, molds and protozoa in foods, as well as the occurrence and control of foodborne pathogens and spoilage organisms. The focus of this first part of the two part lecture (Food Micro II is offered in the FS) will be on the organisms, but also on the factors which determine spoilage and foodborne disease.

Content
1. History of Food Microbiology
1.1. Short synopsis of foodborne microorganisms
1.2. Spoilage of Foods
1.3. Foodborne Disease
1.4. Food Preservation
1.5. VIP's of Food Microbiology
2. Overview of Microorganisms in Foods
2.1 Origin of Foodborne Microorganisms
2.2. Bacteria
2.3. Yeasts
2.4. Molds
3. Microbial Spoilage of Foods
3.1 Intrinsic and Extrinsic Parameters
3.2. Meats, Seafoods, Eggs
3.3. Milk and Milk Products
3.4. Vegetable and Fruit Products
3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
3.6. Drinks and Canned Foods
4. Foodborne Disease
4.1. Significance and Transmission of Foodborne pathogens
4.2. Staphylococcus aureus
4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
4.4. Listeria monocytogenes
4.5. Salmonella, Shigella, Escherichia coli
4.6. Vibrio, Yersinia, Campylobacter
4.7. Brucella, Mycobacterium
4.8. Parasites
4.9. Viruses and Bacteriophages
4.10. Mycotoxins
4.11. Bioactive Amines
4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

Literature
Recommendations will be given in the first lecture

Food Science General Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Kopf, A. Oxenius</td>
</tr>
</tbody>
</table>

Abstract
Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response.
Objective
Introduction into structural and functional aspects of the immune system.
Basic knowledge of the mechanisms and the regulation of an immune response.

Content
- Introduction and historical background
- Innate and adaptive immunity, Cells and organs of the immune system
- B cells and antibodies
- Generation of diversity
- Antigen presentation and Major Histoincompatibility (MHC) antigens
- Thymus and T cell selection
- Autoimmunity
- Cytotoxic T cells and NK cells
- Th1 and Th2 cells, regulatory T cells
- Allergies
- Hypersensitivities
- Vaccines, immune-therapeutic interventions

Lecture notes
Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"

Literature
- Kuby, Immunology, 9th edition, Freemen + Co., New York, 2020

Prerequisites / notice
For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
</tr>
<tr>
<td>Project Management</td>
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</tbody>
</table>

Social Competencies
Communication

Personal Competencies
Negotiation

752-2120-00L Consumer Behaviour I
W  2 credits  2V  M. Siegrist, A. Bearth, A. Berthold

Abstract
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

Objective
Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior

752-1003-00L Food Chemistry II
W+ 3 credits  2V  L. Nyström, S. Boulos, M. Erzinger

Abstract
To familiarize with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.

Objective
Recognize chemical structures of the main ingredients and be able to draw them themselves
Understand foods as complex systems and be able to make connections between chemical structures, chemical reactions and their influence on quality.
Recognize chemical reactions of lipid oxidation, Maillard reaction and enzymatic reactions and be able to formulate them themselves.

Content
Selected (possibly changing) food chemistry topics (e.g. sweeteners, polysaccharides, from olive to margarine, etc.)

The lectures Food Chemistry I and Food Chemistry II constitute a unit.

752-1103-00L Food Analysis II
W+ 3 credits  2V  T. Gude

Abstract
To get acquainted with the principles and applications of mass spectrometry in food analytics.

Objective
To get acquainted with the principles and applications of mass spectrometry in food analytics.

Content
Main focus: Mass spectrometry, applications of mass spectrometry (MS).

Lecture notes
The lectures are supplemented with handouts.

752-3001-00L Food Process Engineering II
W+ 3 credits  3G  E. J. Windhab

Abstract
To procure students with the basics of mechanical process engineering with main focus on mechanical unit operations used in the food industry.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1415 of 2416
Lecturers

Documentation and communication of scientific projects is one of the focal points of any scientific work. They take place at different times at the end of the course, the students understand the biological and nutritional underpinnings of physiology with specific examples relating to brain functions.

4P Hours

Food Technology Laboratory Course

Grundtechniken für die mikrobiologische Untersuchung von Lebensmitteln, Qualitätssicherung, Anwendung von antimikrobiellen Methoden, Durchführung von Gentransfermethoden mit Mikroorganismen (Konjugation, Transformation) und Bakteriophagen in Lebensmitteln.

Literature

- Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- Süssmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

Prerequisites / notice

Handouts for each topic will be made available on Moodle.

752-2000-00L Food Materials Science

Principles of soft condensed matter applied to food polymers, surfactants and colloids

Objective

Understanding the fundamental physical principles ruling the self-assembly, aggregation, processing and structure-properties relationship in food systems constituted by polysaccharides (polymers), proteins (colloids) and lipids (surfactants).

752-6307-00L Physiology and Anatomy III

Imparts an advanced understanding of physiology, focusing on the link between nutrition and function of the mammalian organism. This is fostered by discussing all subjects from a viewpoint of health and disease. A major topic of the lectures is the link between nutrition and brain function, including mental health and neurodegenerative disorders.

Objective

At the end of the course, the students understand the biological and nutritional underpinnings of physiology with specific examples relating to brain functions.

Lecture notes

Handouts for each topic will be made available on Moodle.

752-0300-00L Scientific Practices in Food Science

Only for Food Science BSc.

Abstract

Understanding of the scientific approach to literature research, documentation, reporting, and communication of scientific projects and their results.

Content

- Literature (scientific publishing, sources and their quality), literature research, databases
- Writing scientific reports in German and English
- Practical statistics with examples and exercises
- Create graphics and tables
- Creation of a poster
- Assessment, processing, reduction, and storage of data
- Ethics in research (plagiarism, acknowledgements)
- Other relevant topics

Prerequisites / notice

keine

Number Title Type ECTS Hours Lecturers

752-4007-00L Experimental Food Microbiology

Number of participants limited to 48.

Registration only after having attended the course Lebensmittel-Mikrobiologie I (752-4005-00L).

Abstract

Teaching of basic experimental knowledge for detection and identification of relevant microorganisms in food. Various practical experiments were accompanied by theoretic introductions to the different topics. The students become acquainted with state-of-the-art methods with main focus on modern molecular techniques for the rapid detection of food borne pathogens.

Objective

Teaching of basic experimental knowledge for detection and identification of relevant microorganisms in food.

Content

Grundtechniken für die mikrobiologische Untersuchung von Lebensmitteln, Qualitätssicherung, Anwendung von antimikrobiellen Methoden, Durchführung von Gentransfermethoden mit Mikroorganismen (Konjugation, Transformation) und Bakteriophagen in Lebensmitteln.

Lecture notes

Wird am Praktikumsanfang abgegeben.

Literature

- Krämer: "Lebensmittel-Mikrobiologie" (Ulmer; UTB)
- Süssmuth et al.: "Mikrobiologisch-Biochemisches Praktikum" (Thieme)

Prerequisites / notice

Important information!

During the course we will work with the food-borne pathogen Listeria monocytogenes. Listeria monocytogenes represents a particular threat in case of pregnancy. Due to biosafety reasons participation is not allowed in case of pregnancy.

752-2002-00L Food Technology Laboratory Course

Number of participants limited to 55

Prerequisite: Attendance of the course 752-2001-00L

"Food Technology".

Abstract

Practical laboratory work on pilot plant scale on important processes for selected foods from the raw material to the final product. Evaluation of food quality.

Objective

Know how and handling of the production from selected manufacturing processes to the preservation of food. Understanding the effects of important parameters to the preservation of food including the evaluation of the raw material and the intermediate as well as final products; Analyzing the effects with defined manufacturing processes on the quality of the final products; Evaluation of scientific and non-scientific information and sources.

Content

This practical course contains different experimental blocks:
- Production of sterile canned goods, determination of sterilization conditions (obligation for all studying)
- Production of long paste goods (humidification, drying process and Characteristic)
- Production and processing of meat-loaf (employment of nitrite salts and their effect)
- Production of potato flakes (Characteristic of the ingredients among other things content of strength and drying process)
- Production of Tofu (from the soy bean to finished Tofu)
- Hot extruding of corn semolina
- Charactistic of wheat flour and production of bread (paste preparing/computations and various analyses)

Lecture notes

All information and the program will be sent to enrolled students prior to the start of the laboratory course by e-mail. The scripts for this course on the page of the course catalogue in learning materials are available online and can be viewed after login.
The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials. The course first offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials. Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.

## Content
This course is structured in 3 blocks:
- **Block (I):** Fundamentals of engineering in biological materials
  - Biological engineering principles
  - Basic building blocks found in biological materials

- **Block (II):** Replicating biological design principles in synthetic materials
  - Biological and bio-inspired materials: polymer-reinforced and ceramic-toughened composites
  - Lightweight biological and bio-inspired materials

- **Block (III):** Bio-inspired design and systems
  - Mechanical actuation - plant systems
  - Bio-inspiration in the built environment

Copies of the slides will be made available for download before each lecture.

Abstract
The course gives an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

## Literature

## Electives
A list with possible electives will be published separately.

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
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</thead>
<tbody>
<tr>
<td>327-1221-00L</td>
<td>Biological and Bio-Inspired Materials</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>A. R. Studart, I. Burgert, R. Nicolas Libanori, G. Panzarasa</td>
</tr>
</tbody>
</table>

Abstract
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The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

Content
Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions.

Lecture notes
Will be provided in parts before each individual lecture.

Literature

Prerequisites / notice
Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.

<table>
<thead>
<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>535-0230-00L</td>
<td>Medicinal Chemistry I</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>J. Hall</td>
</tr>
</tbody>
</table>

Abstract
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Content
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</thead>
<tbody>
<tr>
<td>851-0626-01L</td>
<td>International Aid and Development</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>I. Günther</td>
</tr>
</tbody>
</table>

Abstract
The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.

Prerequisites: Basic knowledge of economics

Does not take place this semester.
Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid. Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.

Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development: Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid: e.g. Micro-Finance, Budget-Support; Fair-Trade.

Articles and book abstracts will be uploaded to a course website.

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and their effects on sustainability challenges related to water, energy, mobility, and food.

Reading materials and slides will be available via Moodle.

The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

A comprehensive script will be made available online on the moodle platform.

This course explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

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The course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and their effects on sustainability challenges related to water, energy, mobility, and food.

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

The course includes an introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

A comprehensive script will be made available online on the moodle platform.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.
Students are able to identify and critically evaluate moral arguments, to analyse and solve moral dilemmas considering different participants of the course Research Ethics will receive guidance to improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter.

Objective

The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project.

Content

Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Lecture notes

No.

The lecture slides and other additional material will be available for download from Moodle a week before each class.
After completing this course:

The following textbook is recommended:

The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms competitive strategies and marketing priorities.

Handouts and working papers.

Subject-specific Competencies

Concepts and Theories
Analytical Competencies
Decision-making
Problem-solving

Method-specific Competencies

Communication
Cooperation and Teamwork

Social Competencies

Creative Thinking
Critical Thinking
Integrity and Work Ethics

Personal Competencies

Communication and Social Competences

Analytical Competencies
Decision-making
Problem-solving

- Braun Walter, Die (Psycho-) Logik des Entscheidens, Fallstricke, Strategien und Techniken im Umgang mit schwierigen Situationen, Zürich 2015.

Does not take place this semester.

Corresponding learning goals

Does not take place this semester.

Case study assignments make up 30% of the final grade. Details on submission and grading are provided within the course and on “Performance Assessment”. The maximum grade can only be achieved if both the exam is taken and all case studies are submitted.

Fostered competencies

1) know tools to "study in a paperless way"; have tried out these tools and made their own conscious choice of useful tools.
2) know tools to work efficiently and goal-oriented in teams.
3) can approach problems methodically correct; know important problem-solving techniques.
4) are able to handle scientific texts and sources correctly; know how to write scientific papers.
5) know how to avoid social problems in workingteams and how to solve them when they exist.

Self-awareness and Self-reflection

Prerequisites / notice

None

Communication and Social Competences

Does not take place this semester.

Introduction in basic skills for increasing the effectiveness and efficiency of students daily work.

Handouts and working papers.

- Stadelwieser Jürg, Kommunikation als Schlüssel zum Erfolg, Tobler, 2000 (vergriffen/Bibliothek).
The lecture deals with problems of tumor epidemiology (causes, mortality, incidence). Cancer is delineated as a multi-step process.

Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- Johann S. Ach et. al (Hrg.), Grundkurs Ethik 1. Grundlagen, Paderborn (mentis) 2008
- Marcus Düwell et. al (Hrg.), Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006
- Konrad Ott/Jan Diers/Kieske/Vogt-Kleschin, Handbuch Umweltethik, 2016

The lecture requires an active participation of the students. All students will participate in individual or group work focusing on specific subject of the lecture. Students will have ample time for preparation during lecture time.

additional information is given during the lecture

The lecture requires an active participation of the students. All students will participate in individual or group work focusing on specific subject of the lecture. Students will have ample time for preparation during lecture time.


On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

The reason for genetic predisposition to cancer will be discussed as well as cancer relevant aspects of cell cycle regulation. The role of tumor microenvironments and phenonemon like angiogenesis and metastasis are presented as well as the mechanisms that protect the genome from mutagenic damage. Further subjects address old and new strategies of cancer treatment. Personalised cancer treatment.

The lecture requires an active participation of the students. All students will participate in individual or group work focusing on specific subject of the lecture. Students will have ample time for preparation during lecture time.

additional information is given during the lecture

- Konrad Ott/Jan Diers/Kieske/Vogt-Kleschin, Handbuch Umweltethik, 2016
- John O'Neill et al., Environmental Values, 2008
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.
Objective
This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content
The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

Bachelor's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>752-0220-20L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>15 credits</td>
<td>32D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract
The Bachelor Thesis completes the Bachelor programme and consists of a scientific project carried out independently under the tutorship of a lecturer at D-HEST.

Objective
The Bachelor Thesis aims at fostering the student's ability to independent, structured and scientific working and at deepening their knowledge in a specific field.

Food Science Bachelor - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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<tbody>
<tr>
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<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
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Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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<th>practical/laboratory course</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## General Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>351-0778-00L</td>
<td>Discovering Management</td>
<td>Z</td>
<td>3</td>
<td>3G</td>
<td>B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe</td>
</tr>
<tr>
<td>351-0778-01L</td>
<td>Discovering Management (Exercises)</td>
<td>Z</td>
<td>1</td>
<td>1U</td>
<td>B. Clarysse, L. P. T. Vandeweghe</td>
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<tr>
<td>351-1109-00L</td>
<td>Introduction to Microeconomics</td>
<td>Z</td>
<td>3</td>
<td>2G</td>
<td>M. Wörter, M. Beck</td>
</tr>
</tbody>
</table>

### Discovering Management

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

**Content**

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

**Prerequisite:** Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

**Abstract**

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

**Objective**

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:

1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

Content

The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

**Objective**

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discoering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

**Content**

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

These course materials will form the point of departure for the lectures, class discussions and team work.

Students have the option to either write this alone or in a group of two students.

**Literature**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
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<tbody>
<tr>
<td>Analytical Competencies</td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
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</tr>
</tbody>
</table>

**Introduction to Microeconomics**

**ECTS**: 3

**Type**: G

**Title**: Introduction to Microeconomics

**Prerequisite:** Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory.

**Abstract**

This course is offered complementary to the basis course 351-0778-00L, "Discovering Management". The course offers an additional exercise.

**Objective**

The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

Discoering Management (Exercises) thus focuses on developing the skills and competences to apply management theory to a real-life exercise from practice.

**Content**

Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

These course materials will form the point of departure for the lectures, class discussions and team work.

Students have the option to either write this alone or in a group of two students.

**Literature**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

**Fostered competencies**

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<td>Communication</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td>Critical Thinking</td>
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</table>

**Note for D-MAVT students:** If you have already...
successfully completed “Principles of Microeconomics” (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models. They acquire the ability to apply these models in the interpretation of real world economic contexts.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course “Einführung in die Mikroökonomie” (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 “Principles of Microeconomics” for Master students.

Fostered competencies

<table>
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<th>Subject-specific Competencies</th>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td></td>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

351-0511-00L Managerial Economics

Not for MSc students belonging to D-MTEC!

Abstract
"Managerial Economics” provides an introduction to the theories and methods from Economics and Management Science to analyze economic decision-making in the context of markets. The course targets students with no prior knowledge in Economics and Management.

Objective
The objective of this course is to provide an introduction to microeconomic thinking. Based on the fundamental principles of economic analysis (optimization and equilibrium), the focus lies on understanding key economic concepts relevant for understanding and analyzing economic behavior of firms and consumers in the context of markets. Market demand and supply are derived from the individual decision-making of economic agents and market outcomes under different assumptions about the market structure and market power (perfect competition, monopoly, oligopoly, game theory) are studied. This introductory course aims at providing essential knowledge from the fields of Economics and Management relevant for economic decision-making in the context of both the private and public sector.

Literature

Prerequisites / notice
The course targets both Bachelor and Master students. No prior knowledge in the areas of Economics and Management is required.

351-1034-00L Microeconomics

Not for students belonging to D-MTEC!

Abstract
Introduction to the economic decisions of households and firms, and their coordination through markets. Analysis of different market structures and of situations in which markets may lead to socially undesirable outcomes.

Objective
Understanding of basic microeconomic models. Ability to apply these models to real world economic situations.

Content
Economics as a science, division of labour and welfare (concept of comparative advantage), supply and demand (market equilibrium, elasticity), households (preferences, demand), firms (technology, cost analysis, profit maximisation, supply), perfect competition, monopoly and oligopoly, externalities, public goods, information, factor markets and income distribution

Lecture notes
via email

Literature

Prerequisites / notice
Course macroeconomics in the spring term
Economics

The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization. The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

After successful completion of the course you will be able to:
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

Prerequisites / notice

Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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<td>Critical Thinking</td>
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<td>Problem-solving</td>
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</table>

351-1158-AAL

Principles of Economics

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Students understand basic microeconomics and macroeconomics problems and theories. They are able to argue along economic principles and to judge policy measures.

Objective

Upon successful completion of the course, you will be able to:

- Describe the basic microeconomic and macroeconomic problems and theories.
- Make economic arguments to a given topic.
- Evaluate economic measures.

Content

Households, firms, supply and demand: How are household preferences and consumption behavior formed? How does a household react to price changes? How are goods prices formed? At what prices are firms willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can governments influence the market?

Market failure: What happens when prices give wrong signals?

Labor market: How do supply and demand work in the labor market? What influences unemployment?

National Accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work, and what happens when there is too much (or too little) money on the market?

Literature


363-0541-02L

Systems Dynamics and Complexity (Additional Cases)

Only for Mechanical Engineering BSc.

Abstract

This module is an addition to the course Systems Dynamics and Complexity. It offers additional study cases to MAVT Bachelor students who enroll in the main course.

Objective

MAVT Bachelor students learn how to develop and analyze more sophisticated systems dynamics models from different areas, e.g. from biology (population dynamics, cooperation), management (inventory modeling, technology adoption and economics (supply and demand, investment and consumption)), to name but a few. The goal is to apply analytical and numeric techniques to gain a deeper understanding of the dynamics of complex systems.

Content

1. Modelling path dependence and formation of standards
   - Why do clocks go clockwise? Why do people in most nations drive on the right? Why do nearly all computer keyboards have the QWERTY layout, even though it is more inefficient compared to DVORAK? It turns out that many real-world processes are path depended, i.e. small random events early in their history determine the ultimate end state, even when all end states are equally likely at the beginning. Students will learn how to model such processes, to understand the feedback mechanisms that lead to path dependence. As a case in point, we will study the ‘war’ between the Betamax and the VHS standards.

2. Optimal migration as promoter of cooperation
   - Mechanisms to promote cooperative behaviour is a vibrant research topic in various fields - economics, evolutionary biology and management science to name but a few. Students will be introduced to one such mechanism - migration. They will develop and analyse a macroscopic model to study how the rate of migration affects the long-term cooperation rate in a population.

3. Information transfer
   - Information flow in a social system (e.g. about the location of resources or appearance of a competitor) is an important component of group living. For example, it is well known that ants can achieve remarkable feats in finding an optimal route to a food patch through pheromone trails. The goal of this study case is to model information transfer in such systems by investigating the dynamics of trail formation in ants. The students will learn that the complexity in navigating to a food source may nevertheless be explained as a simple dynamical system with one control parameter only.

4. Decisions in social societies
   - In many situations individuals have to decide between two or more options. Such decisions often have a profound impact on the system as a whole, especially regarding group cohesion. Group cohesion is preferred, as individuals can benefit from living in groups, yet it may not be the underlying reason behind individual choices. In this case, students will develop and extend a macroscopic model of an animal social system faced with a decision to choose a new home, and identify the conditions which promote group cohesion versus group splitting.

5. Antigenic variation of HIV
   - One of the characteristic traits of HIV is that a host can be a carrier and a transmitter of the virus without experiencing symptoms for up to 10 years. This case is concerned with finding the mechanism of HIV disease progression. The students will develop a general population-based model for the interaction of an infectious agent with the host immune system. The model is applicable to a variety of infectious agents, ranging from acute lethal infections to chronic illness. Through analysing and simulating the model, the students will understand how the HIV virus interacts with the host and how the mutation rate of the virus is ultimately responsible for this long asymptomatic period.

6. Compartimental models in epidemiology
   - Many diffusive processes in social systems, such as epidemics, can be understood as a result of the interaction between a few groups (compartments) of individuals. The most common example is to divide a population into those who are susceptible (S) to a disease, those who are infected (I), and those who have recovered (R) and are immune, and to model their interactions. These so called SIR models find wide application in studying non-biological diffusive processes, e.g. spread of technological innovations, fads, internet memes etc. In this study case, students will become familiar with the basic components of an SIR model and the conditions under which a disease can cause the outbreak of an epidemic. Students will extend the basic model to investigate more realistic scenarios relevant to e.g. different vaccination strategies.
### Management, Technology and Economics (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
<th>Key</th>
</tr>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Z</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Dr</td>
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<tr>
<td>W</td>
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### Key for Hours

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<th>Letter</th>
<th>Description</th>
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<td>D</td>
<td>Diploma thesis</td>
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<td>R</td>
<td>Revision course / private study</td>
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### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Welcome and Introduction to MSc ETH MTEC
Monday, 19.09.2022, 14.00 - 15.15 h, HG E 1.1

Core Courses

Financial Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
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<td>363-0711-00L</td>
<td>Accounting for Managers</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>H. Chen</td>
</tr>
</tbody>
</table>

Abstract
The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

Objective
By attending this course, students will be able to:
- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

Content
The first part of the course is devoted to financial accounting. It teaches the principles of double-entre accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

Prerequisites / notice
This course is a prerequisite for the course Financial Management.

363-0561-00L Financial Market Risks

Abstract
I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

Objective
The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

- Development of the concepts and tools to understand these risks and master them.
- Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)
- Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks

Autumn Semester 2022
### Content

1- The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of the perpetual money machine.

2- Risks in financial markets
- What is risk?
- Measuring risks of financial assets
- Introduction to three different concepts of probability
- History of financial markets, diversification, market risks

3- Introduction to financial risks and its management.
- Relationship between risk and return
- Portfolio theory: the concept of diversification and optimal allocation
- How to price assets: the Capital Asset Pricing Model
- How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4- Financial markets: role and efficiency
- What is an efficient market?
- Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
- Deviations from efficiency, puzzles and anomalies in the financial markets
- Financial bubbles, crashes, systemic instabilities

5- An introduction to Options and derivatives
- Calls, Puts and Shares and other derivatives
- Financial alchemy with options (options are building blocks of any possible cash flow)
- Determination of option value; concept of risk hedging

6- Valuation and using options
- A first simple option valuation model
- The Binomial method for valuing options
- The Black-Scholes model and formula
- Practical examples and implementation
- Realized prices deviate from these theories; volatility smile and real option trading
- How to imperfectly hedge with real markets?

7- Real options
- The value of follow-on investment opportunities
- The timing option
- The abandonment option
- Flexible production
- Conceptual aspects and extensions

8- Government bonds and their valuation
- Relationship between bonds and interest rates
- Real and nominal rates of interest
- Term structure and yields to maturity
- Explaining the term structure
- Different models of the term structure

9- Managing international risks
- The foreign exchange market
- Relations between exchange rates and interest rates, inflation, and other economic variables
- Hedging currency risks
- Currency speculation
- Exchange risk and international investment decisions

### Lecture notes

Lecture slides will be available on the site of the lecture

### Literature

Corporate finance
Brealey / Myers / Allen
Eight edition

+ Additional paper reading provided during the lectures

### Prerequisites / notice

None

### General Management and Human Resource Management

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

**Abstract**

This course is an introduction to the critical management skills involved in planning, organizing, leading and controlling an organization.

**Objectives**

By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate routine operations in order to meet evolving customers' and societal needs. The students will achieve these goals by being able to:

- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how change, internally or externally initiated, impact such relationships

**Content**

This course is an introduction to critical management skills involved in planning, organizing, leading and controlling an organization. This course follows a 'systemic' view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations: Input (i.e., from external environment), strategy, people, work, formal and informal structure of the organization, and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements together by means of real-life cases, whereby the focus will be on the critical reflection of particular cases of fits and misfits between those elements and on the application of a selection of tools and methods.
The content of the course will rely on different readings, cases and selected chapters of following book:

Selected readings from the book and additional learning materials will be available on the course Moodle:
https://moodle-app2.let.ethz.ch/course/edit.php?id=17562

The content of the course will rely on different readings and on selected chapters of following book:

Selected readings from the book and additional learning materials will be available on the course Moodle:
https://moodle-app2.let.ethz.ch/course/edit.php?id=17562

Prerequisites / notice
Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on moodle. This preparation is required to participate in the lectures.

The final exam is requested for all types of students (BSc, MSc, MAs, PhD, and Exchange students). It is not possible to retake the exam within the same term or academic year.

We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.

Fostered competencies

Information Management and Operations Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>363-0421-00L</td>
<td>Management of Digital Transformation</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>E. Fleisch</td>
</tr>
</tbody>
</table>

Abstract
This course provides an overview of Digital Transformation within organizations, the opportunities that come with it, but also the issues managers face transforming their organizations into the digital age. Increasingly, information technology (IT) is not only being used as a tool to improve processes but to also create and capture new customer value and to gain and maintain competitive advantage.

Objective
This course introduces to the students the relevant subjects that form the digital transformation agenda of organizations' top-level management. After completing the 4 core learning blocks below, students will be able understand, analyze and critically question organization's digital transformation processes while also learning the frameworks and tools used by organizations to digitally transform.

1. Digital transformation strategies
2. Organizing the digital transformation
3. Digital transformation and technology
4. Digital transformation within industries

Content
Digital Transformation has become a top management theme in almost all forms of organizations and departments within organizations across all industries. It is part of the strategic agenda of management and supervisory boards with dedicated roles to drive forward its design and implementation.

The lecture introduces many of the relevant subjects that together form the digital transformation agenda of organizations’ top-level management. It establishes the main themes, tools, and theoretical concepts. The lecture consists of 4 learning blocks, each with a focus on an area of Digital Transformation, and will feature guest lecturers from industry. The lecture is structured as follows:

Block 1: Strategy
• Digital Business Model Patterns
• Platform Companies
• Subscription Models
• Lessons from Theory Toolbox

Block 2: Organizational
• Towards an Agile Organization

Block 3: Technology
• “Future-proof” Infrastructure

Block 4: Industry
• Digital Transformation in the Health Care Industry
• Digital Transformation in the Automotive Industry

The course is divided into an onsite classroom part and an online self-learning part. All teaching materials will be available through the course page on Moodle.

All lecture content is provided via the Moodle platform.

All relevant literature is provided via the Moodle platform.

Lecture notes
All lecture content is provided via the Moodle platform.

Literature
All relevant literature is provided via the Moodle platform.

Fostered competencies

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<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>363-0445-00L</td>
<td>Production and Operations Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>T. Netland, H. Franke</td>
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</tbody>
</table>

Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Method-specific Competencies
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication

Personal Competencies
- Creative Thinking
- Critical Thinking

Adaptability and Flexibility
- not assessed
- not assessed
- not assessed
- not assessed
- not assessed

Creative Thinking
- not assessed

Critical Thinking
- not assessed

Integrity and Work Ethics
- not assessed
### Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

### Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to design an operations strategy.
2. Students can analyze forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

### Content
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the functions? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM

Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:

2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Suggested literature is provided in the syllabus.

### Literature

#### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Media and Digital Technologies</td>
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<td>Personal Competencies</td>
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<td>Self-direction and Self-management</td>
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</table>

### 363-0453-00L Strategic Supply Chain Management

**W+ 3 credits 2G  S. Wagner**

#### Abstract
The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms' competitive strategies and marketing priorities.

#### Objective
After completing this course:

1. Students can explain the importance of supply chain management for a firm's strategy and success
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chains and their applicability in specific company and sector settings
4. Students can describe and evaluate fundamental logistics and supply chain concepts
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
6. Students are familiar with current developments and trends in supply chain practices

#### Content
Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains have to be aligned with and support the achievement of the firm's corporate, business, and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains.

Starting with the corporate strategy, firms align their supply chain strategies. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain's role within a firm and the implications of supply chain strategies for firm performance are the foundations of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course not assessed

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It not assessed

tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation? Prerequisites / notice

The following textbook is supplementary: Hopp, Wallace J. (2008); Supply chain science, New York: McGraw-Hill/Irwin

Case study assignments make up 30% of the final grade. Details on submission and grading are provided within the course and on “Performance Assessment”. The maximum grade can only be achieved if both the exam is taken and all case studies are submitted. Students should install MS Excel and the Excel Solver before class, as it is used for within-class exercises. Students without the program and add-in installed may nevertheless participate within groups during the exercises.

Micro and Macroeconomics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>J.-E. Sturm</td>
</tr>
</tbody>
</table>

Abstract

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates.

Objective

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

Content

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economic policies. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature


This book can also be used for the course ‘363-0503-00L Principles of Macroeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Prerequisites / notice

Case study assignments make up 30% of the final grade. Details on submission and grading are provided within the course and on “Performance Assessment”. The maximum grade can only be achieved if both the exam is taken and all case studies are submitted. Students should install MS Excel and the Excel Solver before class, as it is used for within-class exercises. Students without the program and add-in installed may nevertheless participate within groups during the exercises.

Micro and Macroeconomics

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<tr>
<td>363-0503-00L</td>
<td>Principles of Microeconomics</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Filippini</td>
</tr>
</tbody>
</table>

Abstract

This lecture introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

Objective

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches of microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programmes. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
N. Gregory Mankiw and Mark P. Taylor (2020), "Economics", 5th edition, South-Western Cengage Learning. The book can also be used for the course "Principles of Macroeconomics" (Sturm)

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Fostered competencies

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</table>

363-0537-00L Resource and Environmental Economics W+ 3 credits 2G L. Bretschger

Abstract
Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

Objective
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the oversee of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature
### Corporate Sustainability

**ECTS**

<table>
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<th>Number</th>
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<tr>
<td>363-0387-00L</td>
<td>Corporate Sustainability</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Hoffmann, J. Meuer, A. Nunez-Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

**Objective**

**Students**
- assess the limits and the potential of corporate sustainability for sustainable development
- develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method.
- recognize and realize opportunities through team work for corporate sustainability in a business environment

**Content**
The course comprises group work and case studies where the students solve strategic issues of the case companies. In two sessions, the students will also be addressing real-time strategic issues of firms that are represented by executives.

**Prerequisites / notice**
TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

**Lecture notes**
Presentation slides will be made available on moodle prior to lectures.

**Literature**
Literature recommendations will be distributed during the lecture.

**363-0403-00L Introduction to Marketing**

**ECTS**

<table>
<thead>
<tr>
<th>Number</th>
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<tr>
<td>363-0403-00L</td>
<td>Introduction to Marketing</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>S. Brüggemann</td>
</tr>
</tbody>
</table>

**Abstract**
Students who take this course will increase their knowledge of marketing, its effect on consumer behavior and its role in creating long-term value. The course will introduce important concepts, frameworks and methods for marketing decision-making. A focus will be on managing customer relationships with the help of targeted promotions and data collected through digital technologies.

**Objective**

After taking the class, students will be able to:

1. Define what marketing is and describe its role at different stages of the value chain
2. Apply psychological theories to analyze behavior (e.g., purchase behavior) and identify the needs of (prospective) customers in consumer and business markets
3. Design elements of the marketing mix—e.g., develop new products and set prices—in a way that creates long-term value
4. Create an effective and efficient marketing mix that attracts and engages customers, e.g., by running targeted promotions
5. Use quantitative methods and customer data to manage relationships with customers

**Content**
The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making.

The structure of the course will roughly follow the different steps of the value chain, i.e., the set of activities necessary for offering valuable products to customers. First, it will introduce students to psychological theories that help explain behavior, e.g., purchase behavior. It will also familiarize students with different methods from marketing research, which can be used to identify the needs of customers. Next, the course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing. A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

The course is designed to be “hands-on”, with opportunities to apply skills on business cases involving real-world marketing data. It will feature guest lectures from industry experts.

**Literature**

**Fostered competencies**
The course might comprise mandatory and supplemental reading material. Other literature may be assigned in class.

**Subject-specific Competencies**
- Concepts and Theories assessed

**Method-specific Competencies**
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed

**Social Competencies**
- Communication not assessed
- Cooperation and Teamwork not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed

**Personal Competencies**
- Negotiation not assessed
- Creative Thinking not assessed
- Critical Thinking not assessed
- Self-direction and Self-management not assessed

### Strategic Management

**ECTS**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0392-00L</td>
<td>Strategic Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>A.-K. Weiser</td>
</tr>
</tbody>
</table>

**Abstract**
This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at improving and establishing position of firms within an industry.

**Objective**
The lecture “Strategic Management” is designed to teach relevant competences in strategic planning and implementation, for both professional work-life and further scientific development. The course provides an overview of the basics of strategy and the most prevalent concepts and methods in strategic management. The course is given as a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the case companies. In two sessions, the students will also be addressing real-time strategic issues of firms that are represented by executives.
Strategic Management offers a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the involved companies. This aims at offering students a profound theoretical understanding of important and current topics and also offer an opportunity to present these concepts in front of an audience.

This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at analyzing and establishing position of firms within an industry, securing firm performance. Thus, the course focuses on a number of important topics, such as the evolution of industry, industry structure, the analysis of a firm's resources- and knowledge, and innovation.

In addition, student groups will hold presentations on the four main topics of this class, to further develop concepts and enhance understanding. The presentations will cover Industry Dynamics I, Industry Dynamics II, Resource Based View of the Firm, Knowledge Based View of the Firm. For all presentations, selected Harvard Business Cases will be used as a common ground for students to start from.

Students are also expected to read and understand the required readings (approx. 15 items) that cover the most important papers and articles from the past 30 years in management and strategy research. To underline the relevance of Strategic Management in firms, decision makers from companies in Switzerland will be holding guest lectures and give their take on strategy in practice and give insight on current topics in the field.

For further questions and if you are unable to sign up through myStudies, please contact the course assistant:
http://www.smi.ethz.ch/education/practicing-strategy.html

For more information please see:
http://www.smi.ethz.ch/education/practicing-strategy.html

### Technology and Innovation Management

**W+ 3 credits 2G S. Brusoni. A. Zeijen**

This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

#### Objective

This course intends to enable all students to:

- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

#### Content

This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

#### Lecture notes

Slides will be available on the Moodle page

#### Literature

Readings will be available on the Moodle page

#### Prerequisites / notice

The course content and methods are designed for students with some background in management and/or economics

#### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Critical Thinking</td>
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</table>

#### Quantitative and Qualitative Methods for Solving Complex Problems

**363-0389-00L**

**Empirical Methods in Management**

**W+ 3 credits 2G S. Tillmanns**

In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evidence-based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created videos.

The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.
Content

Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understand of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.

The lecture will be taught in presence. There will be individual assignments that students have to solve throughout the lecture. In addition to that, there will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.

Literature

A printed script will be made available. Literature and readings will be announced. For a basic understanding we recommend the Handbook of Good Research by Jürgen Brock and Florian von Wangenheim.

Prerequisites / notice

The course includes out-of-class assignments and projects to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups.

Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.

<table>
<thead>
<tr>
<th>363-1004-00L</th>
<th>Operations Research</th>
<th>W+</th>
<th>3 credits</th>
<th>2G</th>
<th>S. Büttikofer van Oordt</th>
</tr>
</thead>
</table>

Abstract

This course provides an introduction to operations research methods in the fields of management science and economics. Prerequisite mathematical concepts are introduced with a practical, problem-solving perspective.

Objective

- Introduction to building and using quantitative models in a business / industrial environment
- Introduction to basic optimization techniques (Linear Programming and extensions, network flows, integer programming, dynamic and stochastic optimization)
- Understanding the integration of quantitative models into the managerial decision process

Content

The economic environment of today’s companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative models and methods of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analysed and optimized using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:
- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management

The lecture notes

A printed script will be made available.

Literature

Any standard textbook in Operations Research is a useful complement to the course.

Prerequisites / notice

Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.

<table>
<thead>
<tr>
<th>363-0541-00L</th>
<th>Systems Dynamics and Complexity</th>
<th>W+</th>
<th>3 credits</th>
<th>2G</th>
<th>F. Schweitzer</th>
</tr>
</thead>
</table>

Abstract

Finding solutions: what is complexity, problem solving cycle.

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

Objective

A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics
Content

Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling. The course is structured along three main tasks:

1. Finding solutions
2. Implementing solutions
3. Controlling solutions

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see "Prerequisites").

Lecture notes

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

Elective Courses

Economic Dynamics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-1137-00L</td>
<td>Applied Econometrics in Environmental and Energy Economics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>D. Cerruti, S. Srinivasan</td>
</tr>
</tbody>
</table>

It is highly recommended to take 363-0570-00L Principles of Econometrics first.

Abstract

The course introduces to the most common empirical methods for the analysis of issues in environmental, energy, and resource economics. The course includes computer laboratory sessions, and covers the following broad topics: demand models, discrete choice models, empirical methods in policy evaluation, field- and quasi-experiments.

Objective

At the end of the course, the students will be able to: understand the most common empirical methodologies used in environmental, energy, and resource economics; understand the problems the methodologies learnt in class aim to address; appreciate the importance of causal inference in empirical economics; read and understand the research papers in the literature; apply the empirical methods learnt in class using the software R.

Content

The course introduces students to empirical statistical methods that have wide application in environmental, energy, and resource economics and it is divided in four blocks. The first block is a quick review of the basic econometric methodology and concepts (OLS, standard errors, logit/probit models); the second block introduces demand models like the Almost Ideal Demand System, discrete choice models, and their evolutions; the third block explores causal inference in empirical economics and the main reduced-form econometric techniques used in policy evaluation, such as difference-in-differences, regression discontinuity and synthetic control; the fourth block introduces field experiments and instrumental variables, and their characteristics.

At the end of each block there will be a computer laboratory class in which the student will learn to apply the methodologies learnt in class using the statistical open-source software R. Throughout the course, students will have the chance to work on actual data used for analysis in economics papers.

The lectures will make use of current research papers in the literature to illustrate practical examples in which the methodologies learnt in class have been used. Students will be expected to read in advance the paper that will be explained during the lecture. The evaluation policy has the aim to allow students to get practical experience on the econometric methodologies learnt in class. Thus, beyond a final open-book computer exercise exam (60% of the grade), the course includes short takehome computer exercises (40% of the grade).

As the course will be centered on econometric methods, it is recommended that students have taken 363-0570-00L Principles of Econometrics first, or have otherwise a solid knowledge of basic econometric methodologies as detailed in Part 1 of Wooldridge, Jeffrey M. (2018) Introductory Econometrics : A Modern Approach. Seventh ed. ISBN: 978-1-337-55886-0. Knowledge of statistical software R is helpful, but not required and will be taught in the computer laboratory sessions.

Prerequisites / notice

It is highly recommended to take 363-0570-00L Principles of Econometrics first.
Content

1. Introduction
2. The Arrow-Debreu Approach and Sequential Markets
3. The Neoclassical Growth Model and the Representative Agent Model (with Mathematical Background)
4. Technological Progress and how the World has developed
5. Innovations and Growth (New Growth Theory)
6. Growth Policies and Fundamental Causes for Growth
7. Digitization and Artificial Intelligence

Literature

14. Current Literature on Digitization and Artificial Intelligence

Prerequisites / notice

Students who have successfully completed the course "Dynamic Macroeconomics" (364-0559-00L) or "Economics of Innovation and Growth" (363-0562-01L) cannot register for this course.

363-1037-00L Fiscal Competition and Multinational Firms W 3 credits 2V M. Köthenbürger, M. Stimmelmayr

Abstract
The course enables students to understand how multinational firms respond to differential tax regimes in a global economy and how countries strategically use the tax system to host multinationals. In particular, the course covers transfer pricing issues, internal financing decisions and agency problems and their relation to tax policy.

Objective
- Understanding how taxes influence decisions of multinational firms
- Develop thinking about the strategic use of differential tax systems for multinational firms
- Evaluate options for governments to respond to the tax planning behavior of multinational firms
- Using theoretical models and empirical analysis to uncover regularities in how multinational firms respond to taxes

Content
Multinational firms have grown in importance in recent decades. Given that their affiliates are located in different countries, they face various tax systems. This creates complexity with respect to the operation of a multinational firm, but also offers the option to benefit from differences across various tax provisions. Starting from this observation, the course looks at how multinational firms respond to the differences in tax provisions and how governments will respond to this behavior in its choice of tax systems. Different channels how multinational firms allocate taxable profits across countries will be analyzed: transfer pricing policies, internal financing decisions and investments. A particular emphasis will be put on how agency problems within multinational firms interact with tax avoidance behavior and how they are related to tax policy.

The course has two parts: The first part of the lecture contains a detailed treatment of the different channels multinational firms can use to strategically allocate profits to low-tax countries and how the tax avoidance decision might interfere with other decisions of the multinational firm. Building on this insight, we will discuss whether governments might strategically choose to adjust its tax provisions either to benefit from the multinational firm tax-saving behavior or to protect its tax base against the tax-planning behavior. In the second part of the course, we will discuss different papers that empirically analyze the validity of the different channels we have discussed in the first part. Students select one paper out of a list of papers (to be distributed in the course) and give a short presentation of the paper (max. 30 minutes). Afterwards, we will enter a discussion of the presented paper and clarify unaddressed issues.

363-0585-00L Intermediate Econometrics W 3 credits 2V G. Masliorens Fuentes

Abstract
The aim of the course is to discuss different econometric models and their empirical applications. We will cover cross-sectional linear and non-linear regression models, models for estimating treatment effects, and linear panel data models.

Objective
By the end of the course, students should understand the different existing approaches, their applicability, and their advantages and disadvantages. They should be able to read and understand regression output tables. Additionally, students will be able to apply the estimation approaches in practice using STATA.
The lecture provides an introduction to some of the central issues in labor economics, including the determinants of labor supply, firms' demand for workers, minimum wages, unemployment, wage inequality, labor market discrimination, and labor market imperfections. It presents recent empirical research papers on these issues and discusses the empirical challenges related to their research designs.

After taking this course, students will be able to:
- analyze the behavior of actors in the labor market within the conceptual framework of economic theory.
- explain phenomena such as unemployment, wage inequality, labor market discrimination, and labor market imperfections.
- comment on policy-relevant issues such as minimum wages, a universal basic income, immigration, and unemployment insurance.
- comprehend and present the results of the relevant empirical studies on these issues.
- understand the challenges associated with a causal identification of research questions in the social sciences.
- comprehend the idea behind important statistical methods that modern empirical researchers apply to overcome these challenges.

In the course, students will get answers to relevant questions about modern labor markets: Who works, how much, and why? Do people work less if they have a universal (guaranteed) income or pay higher taxes? How does a firm determine its employment? Does a minimum wage reduce the employment of workers it intends to help? How does unemployment arise? What does unemployment insurance do, and what are its effects? What has driven the surge in wage inequality in developed countries in the last decades? What are the effects of immigration on resident wages and employment? Is there wage and hiring discrimination against women, men, and foreigners in the labor market, and why does it arise?

After presenting how modern labor economics conceptualizes these issues, the course discusses state-of-the-art empirical research papers that answer these questions. In the context of the topics, the course thus introduces students to basic statistical methods and data analysis techniques, including regression analysis and quasi-experimental methods. Students will also learn how empirical researchers use big data to get from correlations to causality. This introduction to modern applied economics does not require any prior background in economics or statistics.

The lecture targets students interested in the functioning of labor markets and the academic debate about specific labor market policies. A second target group is students that want to learn how modern empirical research in labor economics uses big data to analyze central issues in labor economics. Students are expected to participate in the in-class discussions actively. They will also have the opportunity to read and present a key research paper on one of the topics discussed in class. The performance will be assessed based on a written exam at the end of the semester.

### Content

The lectures will consist of both theoretical and practical components. In the theoretical part, we will discuss each estimation approach in detail. The lecture will present the assumptions, derivations, as well as the advantages and disadvantages of the estimation approach.

In the empirical part, we will look at simulation results using artificial data. Furthermore, we will investigate a particular research question using STATA.

The course will tentatively cover the following subjects:
- review of ordinary least squares (OLS) estimation
- instrumental variable estimation and two-stage least squares estimation
- seemingly unrelated regression models
- simultaneous equation models
- maximum likelihood estimation
- binary response models
- count data models
- censored and truncated regression models
- sample selection models
- treatment effect models
- static linear panel data models (random effects and fixed effects estimation)

For the theoretical portions of the lectures, we will prepare slides for in-class discussion. Slides will be distributed electronically before each lecture.

For the applied portion of the lectures, we will provide STATA do files, log files, and data sets.

Problem sets will also be made available after every lecture. These problem sets will not be collected or graded, but students can use them in order to prepare for the final exam. Solutions will be made available in the following lecture.

While there is no required textbook for the course, we draw from the following texts, which are also recommend for the preparation of the exam:

### Literature


### 363-1159-00L Labor Economics

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>After taking this course, students will be able to</td>
<td>- analyze the behavior of actors in the labor market within the conceptual framework of economic theory.</td>
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<tr>
<td></td>
<td>- explain phenomena such as unemployment, wage inequality, labor market discrimination, and labor market imperfections.</td>
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<tr>
<td></td>
<td>- comment on policy-relevant issues such as minimum wages, a universal basic income, immigration, and unemployment insurance.</td>
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<td>- comprehend and present the results of the relevant empirical studies on these issues.</td>
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<td>- understand the challenges associated with a causal identification of research questions in the social sciences.</td>
</tr>
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<td>- comprehend the idea behind important statistical methods that modern empirical researchers apply to overcome these challenges.</td>
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In the course, students will get answers to relevant questions about modern labor markets: Who works, how much, and why? Do people work less if they have a universal (guaranteed) income or pay higher taxes? How does a firm determine its employment? Does a minimum wage reduce the employment of workers it intends to help? How does unemployment arise? What does unemployment insurance do, and what are its effects? What has driven the surge in wage inequality in developed countries in the last decades? What are the effects of immigration on resident wages and employment? Is there wage and hiring discrimination against women, men, and foreigners in the labor market, and why does it arise?

After presenting how modern labor economics conceptualizes these issues, the course discusses state-of-the-art empirical research papers that answer these questions. In the context of the topics, the course thus introduces students to basic statistical methods and data analysis techniques, including regression analysis and quasi-experimental methods. Students will also learn how empirical researchers use big data to get from correlations to causality. This introduction to modern applied economics does not require any prior background in economics or statistics.

The lecture targets students interested in the functioning of labor markets and the academic debate about specific labor market policies. A second target group is students that want to learn how modern empirical research in labor economics uses big data to analyze central issues in labor economics. Students are expected to participate in the in-class discussions actively. They will also have the opportunity to read and present a key research paper on one of the topics discussed in class. The performance will be assessed based on a written exam at the end of the semester.

### 363-1021-00L Monetary Policy

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>This lecture will introduce the fundamentals of monetary economics and explain the working and impact of monetary policy. The main aim of this course is to describe and analyze the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, the differences between monetary policy rules and discretionary policy, as well as in institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.</td>
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</table>

The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real-world issues.

### Subject-specific Competencies

- Concepts and Theories: assessed
- Analytical Competencies: assessed
- Problem-solving: assessed
- Communication: assessed
- Sensitivity to Diversity: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed

### 363-1559-00L Microeconomics

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>The main aim of this course is to discuss the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real-world issues.</td>
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The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, the differences between monetary policy rules and discretionary policy, as well as in institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.
Content
For the functioning of today’s economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls either the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today’s major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17629) contains announcements, course information and lecture slides.

Literature
The course will be based on chapters of:

Prerequisites / notice
Basic knowledge in international economics and a good background in macroeconomics.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed</th>
<th>Not Assessed</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<tbody>
<tr>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<th>Social Competencies</th>
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<td>Communication</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<th>Personal Competencies</th>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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363-1161-00L Time Series Econometrics and Macroeconomic Forecasting W 3 credits 2V S. Sarferaz

Abstract
This course introduces the methods for analyzing and forecasting macroeconomic activity using multivariate time series analysis. We will study econometric models that central banks, government agencies and other research institutions use to analyze and forecasts macroeconomic variables.

Objective
How will the overall economy develop during the next quarters and years? What is the impact of the exchange rate on economic activity and inflation? How should we derive macroeconomic scenarios under alternative assumptions about the evolution of key variables like oil prices, exchange rates or the world economic activity? What are the effects of changes in monetary policy, fiscal policy or COVID-19 on economic activity? After completing this course, students will be able to tackle these and related questions using multivariate time series methods as applied by researchers and professional forecasters.

Content
The course covers the following topics:
- Vector autoregressive (VAR) models
- Identification of macroeconomic shocks
- Conditional forecasting (macroeconomic scenario analysis)
- State space models
- Macroeconometrics and Big Data

During computer exercises, we utilize the time series models to study real world examples using R.

Prerequisites:
- Principles of Macroeconomics
- Principles of Econometrics

363-1047-00L Urban Systems and Transportation W 3 credits 2G G. Loumeau

Abstract
This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

Objective
The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.
The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

### Finance and Investment

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>363-1081-00L</td>
<td>Asset Liability Management and Treasury Risks</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Mangold, M. Eichhorn</td>
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<td>Number of participants limited to 40.</td>
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<td>Abstract</td>
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<td>Asset Liability Management (ALM) is key to the financial success of any corporation. The goal is to develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and related profits and losses, including identification and mitigation of undue risks taken. This course is geared towards preparing students to apply these concepts in practical settings.</td>
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<td>- The main learning objectives of this course are:</td>
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<td>- develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and their respective contribution to profits and losses</td>
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<td>- measure and assess exposures to risk factors such as interest and FX rates, equity and commodity prices, as well as liquidity events</td>
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<td>- trading and hedging to mitigate undue risks incurred</td>
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<td>Content</td>
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<td>The course is organized around a series of case studies. We will first discuss and develop an understanding of the fundamentals on different aspects of the management and risk management of the balance sheet. Using real life case studies each concept will then be directly applied and tested. In-class discussions, presentations and one written assignment are used to facilitate active and interactive learning in a stimulating environment. During the case studies students will frequently work in small groups. Therefore, the number of participants is limited to 40.</td>
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<td>The course focuses on the application of finance concepts to the financial management of corporations and is geared towards preparing students to apply these concepts in practical settings. Executive of all sectors are expected to have a sound understanding of the content covered. As such, the course is not exclusively targeted at students who are pursuing a career in the financial services sector. It also recommended for students who want to work in the finance, treasury or risk area of corporates. It is also suitable for students who want to work for a consultancy firm.</td>
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<td>Literature</td>
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<td>No single textbook covers the course, below we list some useful references. Further materials will be made available to students prior to the course.</td>
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**Prerequisites / notice**


**363-0723-00L Corporate Finance**

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<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td></td>
<td>&quot;Corporate Finance&quot; is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.</td>
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**Number of participants limited to 40.**
Objective

Upon successful conclusion of the course, students will ...

1) know what corporate finance and corporate governance are about;
2) be able to price a wide array of corporate securities, assets, and projects, e.g., stocks, bonds, and options;
3) master three valuation approaches (discounted cash-flow valuation, relative valuation, and real-options valuation) and know about their applicability, their strengths, and their weaknesses;
4) know how to finance firms at different stages of their lifecycle;
5) be familiar with terms, acronyms, and concepts in the world of finance;
6) know how to relate real-world corporate events (past and current) to concepts learnt in class;
7) have increased their appeal as future manager, employee or entrepreneur by relevant knowledge in the field of finance in general and corporate finance in particular.

Content

"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

In the following, for each of the three parts of the course, key aspects, are listed.

Part I: Corporate Finance and Corporate Governance
- Corporations and their characteristics (e.g., centralized management, limited liability, free transferability of economic claims, legal personality)
- Corporate finance and its goals (e.g., shareholder-value approach vs. stakeholder-value approach)
- Corporate governance problems and possible solutions (e.g., over-investment, under-investment, self-dealing, monetary incentives, board of directors, the market of corporate control, leverage, product-market competition)

Part II: Investment Decisions/Valuation
- Discounting and compounding
- Present value tools (e.g., perpetuities, growing perpetuities, annuities, growing annuities)
- Bond pricing and interest rates (e.g., types of bonds, term structure of interest rates, yield-to-maturity, duration concepts, forward rates, "riding the yield curve")
- Risk and return (e.g., moments of stock returns, modern portfolio theory, capital market line, systematic risk vs. unsystematic risk)
- CAPM in practice (e.g., computation of the risk free interest rate, beta, and the market risk premium; security market line)
- DCF Analysis: Cost of capital and cash flow estimation
- Relative valuation (e.g., earnings multiples, book multiples, sales multiples, fundamental drivers of multiples)
- Real options (e.g., option to abandon, option to delay, option to expand)

Part III: Financial Policy
- Corporate financing (e.g., instruments, internal vs. external financing, equity financing vs. debt financing, crowdfunding, M&M and beyond)
- Payout policy (e.g., dividends, par value reductions, share buybacks, M&M and beyond)

Lecture notes

Slides in English (and any other relevant material) will be available for download on the following website: https://moodle-app2.let.ethz.ch/course/view.php?id=4479

Literature

For the exam, only the material provided will be relevant.

However, interested students may refer to the following textbook for an alternative, or a complementary, reading:


Human and Entrepreneurial Behaviour

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<th>Number</th>
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<tr>
<td>363-1082-00L</td>
<td>Enabling Entrepreneurship: From Science to Startup</td>
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<td>3</td>
<td>2V</td>
<td>A. Sethi</td>
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Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The students should submit the necessary information until 19 September 2022 and apply to anisethi@ethz.ch

Abstract

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective

Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea
The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders' agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.
The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Group projects related to company cases

There is no script, but slides will be made available before the lectures.

There are texts for each of the course topics made available before the lectures.

The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

### Technology Entrepreneurship (363-0790-00L)

**W 2 credits 2V F. Hacklin**

**Abstract**
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

**Objective**
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

**Content**
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, ...)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.


### Work Design and Organizational Change (363-0301-00L)

**W 3 credits 2G G. Grote**

**Abstract**
Good work design is crucial for individual and company effectiveness and a core element to be considered in organizational change. Meaning of work, organization-technology interaction, and uncertainty management are discussed with respect to work design and sustainable organizational change. As course project, students learn and apply a method for analyzing and designing work in business settings.

**Objective**
- Know effects of work design on competence, motivation, and well-being
- Understand links between design of individual jobs and work processes
- Know basic processes involved in systematic organizational change
- Understand the interaction between organization and technology and its impact on organizational change
- Understand relevance of work design for company performance and strategy
- Know and apply methods for analyzing and designing work

**Content**
The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterium
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

A list of required readings will be provided at the beginning of the course.

### Human Factors I (376-1177-00L)

**W 3 credits 2V M. Menozzi Jäckli, R. Huang, M. Siegrist**

The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.
Abstract

Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the quality and performance in interaction processes. In the lecture, factors are investigated by basic scientific approaches. Discussed topics are important for optimizing people's health, well-being, and satisfaction as well as the overall system performance.

Objective

The goal of the lecture is to empower students in better understanding the applied theories, principles, and methods in various applications. Students are expected to learn about how to enable an efficient and qualitatively high standing interaction between human and the environment, considering costs, benefits, health, and safety as well. Thus, an ergonomic design and evaluation process of products, tasks, and environments may be promoted in different disciplines. The goal is achieved in addressing a broad variety of topics and embedding the discussion in macroscopic factors such as the behavior of consumers and objectives of economy.

Content

- Physiological, physical, and cognitive factors in sensation, perception, and action
- Body spaces and functional anthropometry, Digital Human Models
- Experimental techniques in assessing human performance, well-being, and comfort
- Usability engineering in system designs, product development, and innovation
- Human information processing and biological cybernetics
- Interaction among consumers, environments, behavior, and tasks

Literature

- Gavriel Salvendy, Handbook of Human Factors and Ergonomics, 4th edition (2012), is available on NEBIS as electronic version and for free to ETH students
- Further textbooks are introduced in the lecture
- Brouches, checklists, key articles etc. are uploaded in ILIAS

Natural Resources

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<tr>
<td>363-1036-00L</td>
<td>Empirical Innovation Economics</td>
<td>W</td>
<td>3</td>
<td>1G</td>
<td>M. Wörter</td>
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<tr>
<td>363-1106-00L</td>
<td>The Economics of Climate Change</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>A. Goussebaile</td>
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</table>

Objective

The course focuses on important factors that drive the innovation performance of firms, like innovation capabilities, the use of digital technologies, environmental and innovation policy and it shows how innovation activities relate to firm performance and to the technological dynamic of industries. We also discuss the implications of the findings for effective economic policy-making.

Objective

The course provides students with the basic skills to understand and assess empirically the technological activities of firms and the technological dynamics of industries. In addition, the aim is to promote the understanding of the essential criteria for innovation policy-making.

Lecture notes

Will be provided in the course and in the e-learning environment: https://moodle-app2.let.ethz.ch/course/view.php?id=15120

Literature

Literature will be presented in the course. For an introduction into the economics of innovation see G. M. Peter Swann, The Economics of Innovation - an Introduction, Edward Elgar, 2009.


Prerequisites / notice

Course is directed to advanced Master-Students and PhD Students with an interest in empirical studies.

Fostered competencies

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<th>Subject-specific Competencies</th>
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<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
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<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
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<td>Self-presentation and Social Influence</td>
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<td>Self-direction and Self-management</td>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1445 of 2416
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course, we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:

1. Understand the anatomy of digital biomarkers
2. Understand the potential and applications of digital biomarkers
3. Be able to critically reflect and assess existing digital biomarkers
4. Be able to design and implement a digital biomarker

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amount of physiological, environmental, and behavioral observations can be collected with consumer-centric devices. To derive clinical meaningful information from this data is, however, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantage as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

**Supply Chain and Information Systems**

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<tr>
<td>363-1163-00L</td>
<td>Developing Digital Biomarkers</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>F. Da Conceição Barata</td>
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**Abstract**
The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

**Objective**
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course, we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:

- Understand the anatomy of digital biomarkers
- Understand the potential and applications of digital biomarkers
- Be able to critically reflect and assess existing digital biomarkers
- Be able to design and implement a digital biomarker

**Literature**


**Prerequisites / notice**

Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.
The lecture treats the main challenges of business transformation and the alignment of corporate development and IT activities. It presents a holistic approach to business transformation projects by introducing an integrated model dealing with three main design areas "strategy", "processes" and "information systems" and applying this model to various case studies.

The goal of the lecture is to understand the main challenges of corporate transformation and to demonstrate the application of a holistic project procedure model for corporate transformation projects with special emphasis on the alignment of business and IT.

The student should understand and be able to explain the main reasons for corporate transformation, the relevant management processes to manage corporate transformation, the interdependencies between strategy, processes and information systems, especially how this three levels interrelate, the critical success factors for the successful accomplishment of large scale corporate transformation projects, the main instruments of project, quality and change management and the different types of resulting IT projects.

The globalization of the world leads to an increasingly faster pace in business transformation. Enterprises have to adapt faster and even faster to the environmental changes in a global economy to remain competitive and to make sure they stay in business. In todays information age this does not only mean to adapt business strategy and business processes but also to adapt information systems to the new circumstances. The fast adaptation thorough large scale corporate transformation projects that change strategy, business processes and information systems is critical to ensure competitiveness for tomorrow. The introduction of new business processes and information systems typically takes years in very complex large scale projects. Many projects fail because of insufficient alignment between decision makers in business and IT. Unclear understanding of the overall project scope, undefined roles and responsibilities, unclear project processes, quality problems and resistance to change are some typical problems found in such projects. The lecture is subdivided into following modules:

Corporate development introduction and motivation.
Parallelization of corporate development and complexity reduction.
Planning process and project portfolio management in corporate development.
Management of large scale projects integration of strategy, processes and information systems.
Quality management in large scale projects.
Project management in large scale projects.
Change management within projects.

The lecture is accompanied by four case studies that are used to exemplify the contents of the lecture by applying the concepts to real situations in corporate life.
With the global increase in interconnectivity, the potential for disruption is everywhere. Modern organisations who build resilience in all

### Abstract

A successful participant of this course will be able to:

- interpret the results of data analysis with regard to the methodological choices and the operationalization of theoretical concepts
- assess potential flaws in research designs that can lead to flawed interpretations of results
- apply a wide variety of statistical models (e.g., regressions, difference-in-difference, network models) to different data sources
- name the difference between statistical models and the advantages (or drawbacks) they hold for different data types
- name the limitations of observational data analysis, especially with regard to causality
- explain the importance of sensitivity and robustness checks for statistical analyses

In summary, a successful participant is able to assess quantitative social science research with regard to its research design, the model choice as well as the interpretation drawn from the estimates and make suggestions for improvements.

### Content

The course makes the link to sociological theories and shows how they can be used to derive testable hypotheses. A strong focus is laid upon the operationalization of different concepts, such as finding an appropriate measure of deviant behavior or the level of anomosity that exists between people at a given time. These measures are tested using appropriate statistical models. Here, the focus is put upon the interpretation (e.g., coefficient sizes and power) as well as the presentation of results (e.g., through marginal effects). Lastly, the course fosters critical thinking by discussing sensitivity and robustness tests. As such, the course offers insights into quantitative research design by following a hands-on approach to the study of societal challenges through social data science.

The course includes a lecture, student-led presentations and an accompanying exercise class. In the exercise class students get the opportunity to run through the whole data analysis process. Starting with data inspection, students operationalize theoretical concepts and test them on various statistical models. Strong focus is put on sensitivity checks, where the effect of changes to the model (i.e., adding another control variable) is assessed.

The course covers various application of quantitative social sciences:

- measuring biases in societies
- analyzing behavior changes (due to internal or external events)
- studying deviant behavior and peer effects
- exploring coordination between people

### Literature


### Prerequisites

The statistical analyses in the course exercises are performed in R. Students should be interested in learning R skills to run sophisticated quantitative analyses.

### Assessed competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Problem-solving
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Negotiation
- Creative Thinking
- Critical Thinking

### Resilience in the New Age of Risk

- Discuss the concept of resilience and related frameworks and concepts, and explain their relevance in different contexts (organizations, infrastructure, social groups...).
- Use and discuss key resilience metrics and use them to analyze infrastructure systems.
- Discuss the role of organizational resilience and describe methods to improve it.
- Describe how resilience is applied in practice.
Our increasingly complex and connected systems face continuously emerging disruptions. Resilience constitutes a fundamental departure from the philosophy of risk-management. With resilience, stakeholders adopt risk mitigation strategies aligned to the theories of complex systems.

It is, however, difficult to learn about resilience, since it applies to an extremely large array of systems and contexts. Moreover, the topic of resilience is surprisingly absent from most university curricula. This course fills a gap and walks you through a mode of thinking that is bound to shape the way risks and disasters are dealt with in our increasingly connected society. Hence, tomorrow’s risk managers will and shall also be “resilience managers”.

This course breaks down the concept of complex systems and their resilience. It introduces some of the different flavors of resilience and provides tools for building it in various socially relevant areas (social resilience, engineered systems resilience, organizational resilience...).

The course is divided in 4 parts.
- Part 1: Foundations of Resilience (2 hours)
- Part 2: Resilience Analysis: Infrastructure Systems (12 hours)
- Part 3: Organizational resilience and sensemaking (6 hours)
- Part 4: Resilience in Practice (4 hours)

Part 1 introduces the concept of resilience, and the framework in which it is applied. The distinction between resilience and risk management is highlighted, as well as how these approaches complement each other. The founding concepts of resilience are explained and illustrated: vulnerability, disruption, absorption, recovery, adaptation, etc.

Part 2 walks you through the analysis of the resilience of infrastructure systems. It introduces the useful metrics of resilience. It provides examples of building resilience into complex systems, by increasing the robustness and recoverability of systems, and reducing vulnerabilities. Finally, students will explore the optimization of infrastructure systems.

Part 3. Every system subject to potential disruptions is managed by a human organization. Sensemaking describes how humans frame the problem. It is a process whereby organizational actors attach meaning to external events to resolve the uncertainty surrounding them. Investing in mindfulness improves personal and organizational resilience and success. Finally, the management of organizational resilience is discussed.

Part 4 will provide examples of the use of resilience by practitioners, with guest speakers from the public and private sector.

This course is aimed at MSc and MAS students, from MTEC and other departments. Ideally, students have a quantitative background and some knowledge of risk management.

The Science and Practice of Resilience, Book by Benjamin D. Trump and Igor Linkov
The course is hybrid (in-person or remote).

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<thead>
<tr>
<th>Subject-specific Competencies</th>
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363-1017-00L Risk and Insurance Economics W 3 credits 2G H. Schernberg

Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
1) the expected utility theory of decision making under risk
2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
6) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.
### Technology and Innovation

#### Number 363-0861-00L
**Alliance Advantage - Exploring the Value Creation Potential of Collaborations**

**Abstract**
The development of new business models coping with the constantly augmenting complexity of technologies and systems as well as ever increasing global competition force organizations to focus on close collaboration with key partners. These alliances are key value creation opportunities and constitute the core part of this lecture.

**Objective**
Learning outcomes professional competence
- The students learn and understand the management basics of inter-firm cooperation and organizational networks (business models, incl. risk, communication, etc.)
- realises the value creation potentials of alliances (added value)
- understand underlying theoretical models (Transaction cost theory, principal agent, game theory)
- Identify and understand specific forms of collaboration (Strat. All., JV, Networks, M&A, etc.)
- Apply tools hands on in real companies (in coll. with companies)

Learning outcomes methodological competence
- Writing academic papers
- Developing structured documentation of interviews
- Transferring theory directly into application
- Contributing to the learning journey

Learning outcomes social competence
- Work together with industrial partners
- Improving communication skills as basics for collaboration
- Developing and applying team work skills
- Coping with conflicts resolution in teams

**Content**
The constantly augmenting complexity of technologies and systems, the increased pressure caused by competition, the need for shortening time-to-market and the thereby implied growing risks force organizations to increasingly focus on core competencies. Collaboration with external partners is a key value creation opportunity for successful ventures. This type of cooperation also has implications on daily management activities. This lecture will provide a better understanding of special requirements needed for management of cooperation issues.

- Introduction to theory and management of inter-firm collaboration and networks.
- Description of the formation, management and evolution of collaborations and networks.
- Collaborations in marketing, development, manufacturing (e.g. NUMMI).
- Special forms of collaborations: mergers & acquisition (e.g. pre- and post-merger activities, joint venture, strategic alliances (e.g. Doz & Hamel, networks, virtual communities)

**Learning journey:**
In an introductory lecture we will give an overview of the theoretical framework and explain the concept of the lecture (first week of semester, Sept. 19, 2019). In weeks 2-5 you will work on a first assignment on six different aspects of the underlying framework: strategy and activities, structure and process, culture and people orientation, interaction and roles, risk and trust, knowledge and learning. This first assignment will give you the basics to participate in the second part (Nov. 7+8, 2019) of this seminar. There you will present the results of the first assignment and get additional theoretical input to perform the 2nd assignment. The second assignment will be to analyze real alliance projects in the partner companies. The final lesson will be used as a best practice exchange (Dec. 19, 2019).

**Lecture notes**
- Lecture script
- Current course material
- Harvard Case Studies
- Reader with current papers

**Prerequisites / notice**
The number of students participating in the lecture is limited to 30.

### Number 363-1051-00L
**Cases in Technology Marketing**

**Abstract**
The seminar “Cases in Technology Marketing” introduces students to key concepts and tools in technology marketing and familiarizes them subsequently with the challenges that (marketing) managers face in technology intensive markets by using real life cases.
Entrepreneurial Leadership

The course is a combination of lectures about concepts/methods, guest lectures, case studies, and individual assignments.

1. Understanding and applying common business tools and frameworks
2. Understanding current challenges of managers in technology intensive markets
3. Defining and analyzing comprehensive business problems using the example of a leading Swiss manufacturing company (Bühler AG)
4. Developing and evaluating different alternative case solutions
5. Making decisions on case solutions, justifying and defending them
6. Transferring case solutions into practice by formulating specific instructions for the management
7. Creation of novel, innovative ideas that help the company to gain a competitive edge
8. Cooperation in teams and coordination of team tasks
9. Adequate communication to and eye-level discussions with C-level managers

Objective

Please register through myStudies to enroll for the course. Slots are assigned on a first-come first-serve basis (in the order of the registration date on myStudies). We will confirm your registration by e-mail. If you have any inquiries about the course, please contact the course assistant.

Abstract

This course focuses on the challenges in managing multi-business corporations, and covers topics related to the vertical and horizontal scope of business activities.

Objective

The course is a combination of lectures about concepts/methods, guest lectures, case studies, and individual assignments.

Content

Large- and medium-sized corporations play a central role in the economic activity of most developed and developing countries. Many of these organizations perform multiple business activities in multiple markets. In the face of increasing international competition, globalization, technological development, deregulation, and the emergence of new markets and industries, operating such a portfolio of business activities poses important managerial challenges forcing corporations to continuously reconsider their vertical and horizontal scope and boundaries.

The course Corporate Strategy draws from a wide range of theories and methods to develop an understanding of the conceptual frameworks, debates, and developments concerning decisions associated with the management of multi-business corporations. We will cover the key questions driving a firm's corporate strategy, including:

- In what markets to compete with which businesses?
- Which activities should be performed by the firm and which should be outsourced (i.e. "make" or "buy" decisions)?
- How do institutional forces impact corporate strategy?

Specifically, we will examine how organizations manage their portfolio of business activities and markets to achieve competitive advantage through vertical integration, cooperative strategies such as strategic alliances and joint ventures, corporate diversification, mergers and acquisitions, diversifies, and globalization/international strategies, and strategic renewal.

Prerequisites / notice

In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 20.08.2021 to Theresa Schachner: tschachner@ethz.ch.

363-0393-00L Corporate Strategy

W 3 credits 2V S. Ben-Menahem

Due to didactic considerations, the number of participants for this course is limited to 45.

Please register through myStudies to enroll for the course. Slots are assigned on a first-come first-serve basis (in the order of the registration date on myStudies). We will confirm your registration by e-mail. If you have any inquiries about the course, please contact the course assistant.

363-1028-00L Entrepreneurial Leadership

Limited number of participants.

Students apply for this course via the official website no later than 21.08.2022 (https://www.mtec.ethz.ch/studies/special-programmes/els.html).

Once your application is confirmed, registration in myStudies is possible.

Abstract

This seminar provides master and PhD students at MTEC with the challenging opportunity of a real case on strategy, innovation and leadership in close collaboration with the senior management of a leading Swiss healthcare company: F. Hoffmann-La Roche AG.

Objective

The general objective of the course is to enable MTEC students to develop leadership skills by dealing with real-world business problems, thinking critically about the concepts discussed in their study programs and learning how to apply these concepts to provide practical implications. It provides students with coaching and mentoring from senior leaders in the company and professors from D-MTEC to bridge the gap between theory and practice.

Prerequisites / Fostered competencies

Having participated in the course Strategic Management by Prof. Georg von Krogh/Dr. Stephan Herting is an advantage but not a requirement.

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Problem-solving

Method-specific Competencies

- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

Personal Competencies

- assessed
- assessed
- assessed

Z. Erden Özkol, S. Brusoni, H. Franke, O. von Dzengelevski, G. von Krogh

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1451 of 2416
This seminar provides ambitious ETH students and doctoral candidates with a rewarding learning opportunity: a real case study of strategy and innovation in close collaboration with the top management of an outstanding company: Georg Fischer.

What you can expect:

You will work in teams on specific high priority assignments that flow from the company. Delving into the assignments you will both contribute to solving strategic issues and have an impact on their implementation at the company.

To gain insight into the company and its culture you will receive briefings from senior management, conduct interviews with experts and run workshops with your case managers. In the final presentations you will pitch your findings to key stakeholders and top management representatives and receive valuable feedback.

Furthermore you will be coached and supported by MTEC professors on the topics of project scoping, problem definition and solving, process improvement, strategy and board presentation.

The course is directed and organised by PD Dr. Zeynep Erden and Dr. Isabel Spicker as part of the MTEC Leadership Development Programme.

What we expect from you:

You are an ambitious ETH student or doctoral candidate who is looking for a rewarding learning opportunity and is eager to go the extra mile. You will work on a real case study of strategy, technology and innovation in close collaboration with the top management of an outstanding Swiss company. The recommendations that you formulate in collaboration with members of your team as well as with internal and external experts will be discussed at the Partner and Director levels. This demands a deep understanding of the company's leadership culture.

In this endeavour you are coached and supported by

- Stefano Brusoni, Chair of Technology and Innovation Management
- Georg von Krogh, Chair of Strategic Management and Innovation
- Torbjorn Netland, Chair of Production and Operations Management
- Zeynep Erden, Lecturer, D-MTEC

Please apply for this course via the official website (https://mtec.ethz.ch/studies/programme-elements/special-programmes/els.html). Apply no later than August 22.

The number of participants is limited to 18.

ECTS: 4

Students receive a certificate.

Industry and Competitive Analysis (ICA) is an essential part of any strategic management process. It contains a very practical set of methods to quickly gain a good grasp of an industry. The purpose of ICA is to understand factors that impact the financial performance of an industry and of firms within that industry, thereby enabling firms to develop effective competitive strategies. As the world witnesses tremendous development in digital technologies, many industries are in the midst of transitioning from analogue to digital business models. Digitalization is radically changing what firms produce and the way they organize their business activities. To adapt to these changes, practitioners and scholars alike need a more advanced set of analytical tools to understand the constantly-changing industries. That is why we have developed our course as ICA 2.0, which provides state-of-the-art tools to gain an updated picture of various industries before and after their digital transformation. In this course, we will study theoretical frameworks, examine evidence from empirical research, and benefit from experience shared by our guest speakers.

Data collected before digital transformation
• Industry performance
• Industry structure

Digitalization
• Digital business models
• Industry structure

Experience in statistical analysis with tools such as SPSS or equivalents is an advantage.

This course aims to:

Students will improve the analytical skills needed to successfully compete in the digital age

Goals of the course
• Students will develop an in-depth understanding of how the structure of an industry impacts both industry-level and firm-level performance
• Students will gain a broad understanding of the impact of digitalization on various industries and develop an in-depth understanding of (at least) one chosen industry
• Students will improve the analytical skills needed to successfully compete in the digital age

The course is organized as a combination of lectures, case studies, and tutored group work involving the selection and analysis of industries, analysis and development of strategies for selected firms, and presentation of results.

Grades:
50% paper/industry report (group)
50% final presentation (group)
This course is built upon a management classic (Competitive Strategy: Techniques for Analyzing Industries and Competitors by Porter, 2004). We also draw from more recent research findings and practitioner-oriented strategy research. Readings associated with each lecture should be done before the lecture day.

To access the journal articles listed below, you have to be within the ETH domain (either directly connected to the ETH network within ETH or using VPN). PDF versions of the Harvard Business Review articles are only available via the class Moodle.

**Literature**

**Competitive strategy**
- Chapter 2 of Porter (2004)
- Case study: Southwest Airlines

**Industry Dynamics**
- Chapter 3 of Porter (2004)
- Case study: Southwest Airlines

**Strategic groups & firm membership**
- ICA in the Digital Age

**Opportunities & Resources**

**Preprerequisites / notice**

Due to high intensity of the tutoring format, the number of students is limited to 30. Students will be accepted according to the order of enrollment in myStudies. Exchange students can register by sending an e-mail to sherath@ethz.ch if facing problems with registration to myStudies. Registration will be handled individually, case by case. E-mails that are sent before the starting date of registration to myStudies will not be accepted.

An electronic confirmation of the registration will be sent out shortly before the start of the semester, which contains an access link to the Moodle page of the course (readings, resources for group works, group assignment).

**Note that class participation is important. Students should make sure that they can attend each weekly lecture prior to registration.**

**Fostered competencies**

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<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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**Abstract**

Students learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop their own research projects.

**Objective**

You will learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop your own research project. The successful completion of the course will help you to:
- Think critically and make compelling arguments about the strengths and weaknesses of published management research
- Find and review appropriate literature and previous research for your thesis
- Develop and frame interesting and relevant research questions and problem statements
- Design your research and choose an appropriate methodology for analysis (specific research methods and techniques are not discussed in this course)
- Structure your manuscript
- Plan and manage your thesis project

This course requires preparation time and completion of an assignment before the first course day. Please check the Moodle course page for more information.

Participation in both sessions and completion of all assignments is required to receive the credit.

Student Learning outcomes - management research course

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<td>363-0887-00L</td>
<td>Management Research</td>
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</table>
The semester project (180 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

The semester project (90 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

The course is required for all M.Sc. students and MAS students who write their master thesis at the Chair of Strategic Management and Innovation.

Objective
The semester project (90 hours) is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

References:

Prerequisites / notice
This course is for all students who write their master thesis at the Department of Management, Technology, and Economics.

The course is graded based on the assignments, peer feedback, and participation in group discussions.

The first assignment is due before the first course day. Please check the assignments on the Moodle coursepage. If you sign up for the course on short notice before the first course day, please advise the lecturer of your registration by email.

### Additional Courses

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<tr>
<td>Abstract</td>
<td>The offer Strategic Career Development has the goal to support students in the development and alignment of their personal &amp; professional goals. Orientation, Goal setting, action plan development, motivation letter, CV, interview training. We will include high level external guest speakers.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>We will discuss and develop answers to the following questions:</td>
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<tr>
<td></td>
<td>What do I want to achieve in my life?</td>
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<tr>
<td></td>
<td>Why is it to important to define goals?</td>
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<tr>
<td></td>
<td>What decision criteria can I use as a guide?</td>
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<tr>
<td></td>
<td>How do potential career paths look like? What are the possibilities?</td>
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<tr>
<td></td>
<td>How does the life cycle of a career look like? What are the alternatives?</td>
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</tr>
<tr>
<td></td>
<td>How do I increase my chances of success/reaching my goals?</td>
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<tr>
<td></td>
<td>How did others do it? What kind of advice can experienced captains of industry give?</td>
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<tr>
<td></td>
<td>Why is a periodic check of my goals and my progress necessary?</td>
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</tbody>
</table>
Content

INTRODUCTION
Awareness building / Overview on the career life cycle / Examples from praxis / Exchange of experiences / Approach for goal setting / Introduction to the success secrets of a career

ORIENTATION AND GOAL SETTING
Class discussion of the success secrets of a career / Orientation on career options / Discussion of possible decision criteria / Initial formulation of concrete goals

External guest speaker: Inspiring Start-up Entrepreneur

CAREER DEVELOPMENT PLANS
Exchange w/ representatives of industries / Personal Values & Norms vs Corporate Identity / Work-Life Balance Gender / Diversity / Summary of discussions / Best practice / Modification/Sharpening of goals

External guest speaker: Representatives from Hilti AG Switzerland

DETAILING OF INDIVIDUAL CAREER PLANS
Development of detailed individual career plans / Next steps / action plan / Tips & Tricks for careers in organizations and entrepreneurship

REVIEW & APPLICATION COUNSELING
Review/check of goals and career plans / Motivation letter / CV / Preparation for interviews

INTERVIEW TRAINING

Prerequisites / notice
Motivation. Strategic long-term view.

► Supplementary Courses

The students have to deepen their knowledge in the area(s) of engineering/natural sciences in consultation with the responsible professor (tutor). Core courses and electives of D-MTEC can not be used as supplementary courses.

Course Catalogue of ETH Zurich

► Industrial Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0879-00L</td>
<td>Practical Training</td>
<td>O</td>
<td>6 credits</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

Abstract
The practical experience gained by the student complements the studies at the Swiss Federal Institute of Technology and prepares her/him for future activities in industry.

Objective
The practical experience gained by the student complements the studies at the Swiss Federal Institute of Technology and prepares her/him for future activities in industry.

► Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>363-0600-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>57D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is supervised by the tutor and normally deals with a subject contained in the major fields. The research will be performed normally within a private company or at the ETH Zurich.

Objective
In the Master thesis students prove their ability to independent, structured and scientific working. The Master thesis is supervised by the tutor and normally deals with a subject contained in the major fields. The research will be performed normally within a private company or at the ETH Zurich.

363-1063-00L  Academic Writing Course

Compulsory for all MTEC MSc students. Attendance of the initial lecture is compulsory. Students who are unavailable at the time of the initial lecture need to take the course in another semester.

Abstract
This course for MTEC MSc students focuses on developing students' English writing skills and their understanding of the disciplinary expectations for academic texts. The course is particularly designed to support students during the thesis writing process.

Objective
After the completion of the course, students are able to:
- understand the concept of plagiarism and cite their sources accurately and appropriately,
- plan the writing process efficiently,
- analyse model texts from the perspective of language use,
- plan, draft, and revise academic texts,
- provide peer review on others' writing,
- write in a clear, precise, concise, and generally reader-friendly manner.

Content
Initial lecture: Writing at MSc level in D-MTEC, avoiding plagiarism, course overview

Workshop 1: The writing process
Workshop 2: Paragraph structure
Workshop 3: Methods
Workshop 4: Figures and tables
Workshop 5: Literature review
Workshop 6: Introduction
Workshop 7: Results, Discussion, Conclusion
Workshop 8: Abstract and Title

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1455 of 2416
Lecture notes: Handouts and self-study materials are available on Moodle.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Analytical Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific</td>
<td>Communication</td>
<td>Cooperation and Teamwork</td>
<td>Communication</td>
</tr>
<tr>
<td>Competencies</td>
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<td>not assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
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<td>Critical Thinking</td>
<td>Self-awareness and Self-reflection</td>
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<tr>
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<td>not assessed</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
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</tbody>
</table>

**Management, Technology and Economics Master - Key for Type**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

**Key for Hours**

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The students will be able to analyse mechanical problems, to formulate and apply design criteria involving strength, local plastification, and safety factors. They will also be able to design and to ensure their mechanical integrity. Starting from the derivation of the basic problem, the concepts are extended to consider anisotropic materials, plasticity, viscoelasticity and viscoplasticity. Examples of engineering applications are discussed.

Abstract

The lecture introduces basic digital circuit components. The first part focuses on logic gates, and their realization with CMOS transistors. Aditionally they will be able to assemble them to create their own digital circuits, gather experience and analysis of simple circuits will be discussed. The second part is dedicated to latches and flip-flops.

Objective

This course introduces students to numerical methods commonly used in engineering with a focus on finite element (FE) analysis. Starting with finite differences and ending with static and dynamic FE problems, students will learn the fundamental concepts of finite elements as well as their implementation and application.

Abstract

Numerical methods and techniques for solving initial boundary value problems in engineering solid mechanics. (heat conduction, static and dynamic mechanics problems of solids and structures). Finite difference methods, indirect and direct techniques, variational methods, main focus on the finite element (FE) method. FE analysis in small strains for applications in structural mechanics and solid mechanics.

Objective

This course offers an introduction to dynamics of engineering systems. The first part focuses on Newtonian dynamics and energy principle to systems of particles and rigid bodies. The second part focuses on the free and forced response of single- and multi-degrees-of-freedom linear systems. Hands-on exercises, computer-based labs and experimental demos will support the theoretical lectures.

Abstract

Only for MAS in Advanced Fundamentals of Mechatronics Engineering

Number Title Type ECTS Hours Lecturers

173-0007-00L Dynamics  Only for MAS in Advanced Fundamentals of Mechatronics Engineering O 5 credits 11G E. Chatzi, V. Ntertimanis, P. Tiso

173-0008-00L Introduction to Digital Electronic Circuits  Only for MAS in Advanced Fundamentals of Mechatronics Engineering O 5 credits 11G A. Emboras

173-0009-00L Statics and Solid Mechanics  Only for MAS in Advanced Fundamentals of Mechatronics Engineering O 5 credits 11G E. Mazza

173-0010-00L Computational Methods  Only for MAS in Advanced Fundamentals of Mechatronics Engineering O 5 credits 11G D. Kochmann, L. De Lorenzis

Literature

The material will be organized in lecture slides. A specific list of books will be offered as useful/supplemental reading.

Cooperation and Teamwork

Problem-solving

Decision-making

Technique and Technologies

Analytical Competencies

Communication

Creative Thinking

Critical Thinking

Numerical methods and techniques for solving initial boundary value problems in engineering solid mechanics. (heat conduction, static and dynamic mechanics problems of solids and structures). Finite difference methods, indirect and direct techniques, variational methods, main focus on the finite element (FE) method. FE analysis in small strains for applications in structural mechanics and solid mechanics.

Lecture notes

Typed lecture notes will be made available online.
Industry Internship
Offered in the Autumn Semester.
Offered for the first time in HS 2024.

Master’s Thesis
Offered in the Autumn Semester.
Offered for the first time in HS 2024.

MAS in Advanced Fundamentals of Mechatronics Engineering - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<td>W+</td>
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Key for Hours

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<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
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ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.


### MAS in Applied Technology

#### Major in Applied Information Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>265-0100-00L</td>
<td>Foundations of Programming</td>
<td>O</td>
<td>3</td>
<td>2A</td>
<td>L. E. Fässler</td>
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<tr>
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<td>Only for CAS in Applied Information Technology and MAS in Applied Technology.</td>
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<tr>
<td>Objective</td>
<td>Students learn...</td>
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<tr>
<td></td>
<td>- how to encode a problem into a program, test the program, and correct errors.</td>
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<td></td>
<td>- to understand and improve existing code.</td>
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<td>- to implement mathematical models as a simulation.</td>
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<tr>
<td>Content</td>
<td>The following programming concepts are introduced during this module:</td>
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<td>1. Variables, data types</td>
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<td>2. Condition check, Loops, logics</td>
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<td></td>
<td>3. Arrays</td>
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<td></td>
<td>4. Functions</td>
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<td></td>
<td>5. Matrices</td>
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<td>6. Data management (SQL)</td>
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</table>

In the practical part of the course, students work on small programming projects with a context from natural sciences. Electronic tutorials are available as preparation.

Prerequisites / notice: No prior knowledge is required for this course. It is based on application-oriented learning. The students spend most of their time working through programming projects and discussing their results with teaching assistants. To learn the programming basics there are electronic tutorials available.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>265-0101-00L</td>
<td>Data Science</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>B. Gärtners</td>
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<td>Only for CAS in Applied Information Technology and MAS in Applied Technology.</td>
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<tr>
<td>Objective</td>
<td>Participants learn about some important computer science concepts necessary for data science. They understand some of these concepts in detail and see the mathematics behind them.</td>
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<tr>
<td>Content</td>
<td>Participants will get an introduction to key computer science concepts underlying current and upcoming technology. The module in particular covers cryptography and digital signatures, networking and distributed algorithms, distributed ledger technology, as well as machine learning (supervised and unsupervised learning). Each topic will be discussed in two different ways: (i) a hands-on and in-depth introduction that allows participants to gain a technical understanding of key ideas. This is supported by simple and concrete examples as well as programming assignments; (ii) a context part that addresses the challenges and limitations encountered in practical applications.</td>
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<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>265-0102-00L</td>
<td>Data Modeling and Computer Vision</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>E. Konukoglu, C. Zhang</td>
</tr>
<tr>
<td></td>
<td>Only for CAS in Applied Information Technology and MAS in Applied Technology.</td>
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<tr>
<td>Objective</td>
<td>This module offers practical knowledge in visual information processing and human computer interactions.</td>
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<tr>
<td>Content</td>
<td>Participants understand basic concepts of visual recognition and human-computer interaction systems.</td>
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<td></td>
<td>The first part of the module will cover basic theoretical knowledge on visual recognition systems of the last two decades, mostly focusing on the most recent advancements in deep learning and convolutional neural networks. The theoretical knowledge will be supported with practical sessions that will allow participants to gain hands-on experience with most commonly used tools and deepen their understanding of the key concepts. The second part provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.</td>
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<tr>
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<th>Hours</th>
<th>Lecturers</th>
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<td>O</td>
<td>3</td>
<td>3V</td>
<td>M. Brandis</td>
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<tr>
<td>Objective</td>
<td>This integration module for CAS “Applied Information Technology” links technical understanding of technology with business strategy based on a set of case studies from practice.</td>
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<tr>
<td>Content</td>
<td>Participants will learn how technology affects businesses and practical issues when using new technologies in incumbent organizations based on a set of case studies. Participants will explore how new information technologies change different aspects of a business, and learn how to evaluate specific risks, costs, and benefits of such technologies. The module will shed light on success factors and common pitfalls when implementing new technologies and respective business changes, and it will specifically address the communication between technical experts and business management. The studied cases are currently planned to focus on artificial intelligence, IoT including edge and cloud computing, blockchain and distributed ledger technologies, and cybersecurity and data protection regulations (subject to change).</td>
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</table>

#### Major in Applied Manufacturing Technology

Offered only in the Spring Semester.

#### Focus Courses Energy or Electronics and Digitization

Offered only in the Spring Semester.

#### Major in CAS in Applied Technology: R&D and Innovation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>247-0200-00L</td>
<td>Fundamentals of R&amp;D and Innovation</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>U. Grossner, C. Ganz</td>
</tr>
<tr>
<td></td>
<td>Only for CAS in Applied Information Technology and MAS in Applied Technology.</td>
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<tr>
<td>Objective</td>
<td>This course provides an introduction to research &amp; development, both as a general activity and as a dedicated function within a corporation. Participants will learn how to organize, conduct and manage individual R&amp;D projects as well as groups of projects. Special emphasis will be given to scientific and technical reporting.</td>
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<tr>
<td>Lecture notes</td>
<td>The course provides the framework of organization, managing and reporting of R&amp;D projects and innovation initiatives. The module will be based on a self-study Polybook.</td>
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</tbody>
</table>
Innovation is more than a good idea: It involves bringing the idea to the market, resulting in a highly differentiating market position. Not only products, also ideas have a lifecycle, from conception through launch, scaling, maintenance, to phase out, and replacement by a new innovation. Each phase is facing particular challenges that will be explored.

In this module, participants will understand the diverse aspects of these phases and the impact on the organization and governance.

In this module we will look at these various aspects of innovation beyond the own organization. This module will wrap up the CAS and put the participants a wide range of experiences in hardware and software, touching every aspect of R&D prototype development. The development will start from the ground up, using pre-fabricated components as little as possible. The participants are encouraged to come up with their own project ideas and pursue them with continual support from APS. Example projects will be available for inspiration and as templates and can be adopted instead of an own idea with as little or as many modifications as desired. Large parts of the project can be completed independently, using freely available software running on the participants' computer and corresponding education resources. Some meetings will be scheduled for teaching and discussion and several hands-on sessions in the APS lab will be necessary for manufacturing and testing of the prototypes.

The topics include
- Conceptualization of an idea and planning the realization
- Mechanical design of housing and mechanical components using CAD software
- Manufacturing of mechanical components using a 3D printer
- Electrical design of circuits and PCBs using ECAD software
- Assembly and soldering of PCBs
- Programming embedded software to run on a microcontroller on the designed PCB
- Testing of the desired functionality and measurement of the electrical workings
- Report of the process, the finished prototype and analysis of generated data

Lecture notes
Course material will be available on Moodle.

Prerequisites / notice
Successful completion of CAS AIT, CAS AMT and CAS AED or CAS ATE.

The thesis should be integrative of the science and technology material and skills learned during the programme, particularly:

• Understand and apply the foundations of the area of science and technology relevant to the topic,
• Understand and describe the technical barriers to applying a technology successfully, and
• Respective documentation using precise and targeted technical language.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>247-0500-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>10</td>
<td>21D</td>
<td>Lecturers</td>
</tr>
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</table>

Abstract
The topic of the independent Master’s thesis should focus on a technical problem and can be related to a specific business case. The problem and technology evaluated are freely selectable, but must be approved in advance by the thesis supervisor.

Objective
The thesis should be integrative of the science and technology material and skills learned during the programme, particularly:

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>247-0201-00L</td>
<td>Innovation – What is and to</td>
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<td>what purpose do we need it?</td>
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<td>Only for CAS in Applied</td>
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<td>Technology: R&amp;D and Innovation and MAS in Applied Technology.</td>
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</table>

Abstract
Innovation is more than a good idea: It involves bringing the idea to the market, resulting in a highly differentiating market position. Not only products, also ideas have a lifecycle, from conception through launch, scaling, maintenance, to phase out, and replacement by a new innovation. Each phase is facing particular challenges that will be explored.

In this module, participants will understand the diverse aspects of these phases and the impact on the organization and governance.

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<th>Number</th>
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</table>

Abstract
The inner working of the R&D organization by exploring roles and processes is investigated.

In most organizations, the R&D organization is the one that delivers the innovation to be brought to the market. In this module, we investigate the inner working of the R&D organization by exploring roles and processes. Since R&D almost always starts with significant uncertainties and unsolved technical problems, governing R&D has to account for these unknowns. As R&D processes take time in which the market environment may change in ways other than predicted at the beginning of a project, external influences have to be continuously monitored as well to enable market success.

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<tr>
<td>247-0203-00L</td>
<td>The Innovation Ecosystem</td>
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Abstract
This module wraps up the various aspects of innovation beyond the own organization.

In this module we will look at these various aspects of innovation beyond the own organization. This module will wrap up the CAS and put the
<table>
<thead>
<tr>
<th>Key for Type</th>
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<tr>
<td>Dr</td>
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**Key for Hours**

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium
- **P**: practical/laboratory course
- **A**: independent project
- **D**: diploma thesis
- **R**: revision course / private study

ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Architecture and Digital Fabrication

The MAS Digital Fabrication is a 1 year full-time programme and is structured as a series of teaching modules with an independent master thesis. Lessons within the modules are given in the form of lectures, practical workshops, and projects as the main modus for developing skills. Learning will be supported through one on one mentoring in studio, group critiques, symposia, and excursions.

Module

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<th>Number</th>
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<tr>
<td>069-0001-00L</td>
<td>Digital Foundations</td>
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<td>20 credits</td>
<td>2G</td>
<td>B. Dillenburger, F. Gramazio,</td>
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<td>Digital Foundations</td>
<td></td>
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<td>M. Kohler</td>
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</table>

Abstract

Digital Foundations introduces students to information technology in architecture, to computational design and how robotic fabrication processes as well as 3D printing technologies are used to translate computational design models into physical objects and building components.

Objective

Students learn basic programming paradigms such as control structures and object oriented programming, the foundations of computational geometry and explore generative form-finding. Using Python as a main programming language within the frameworks of Processing, Rhino and Grasshopper, students learn to translate design thinking into computational algorithms. Furthermore, students learn about data preparation and toolpath creation for 3D printing (predominantly binder jet-printing and fused-deposition-modelling), and familiarise themselves with various mechatronic setups, materials and control-strategies of additive manufacturing.

Students are taught the basic principles of working with industrial robotic arms in the field of architecture. Students practice different concepts of robotic control, which enables them to execute basic routines. They are able to write their own programmes and directly control the robotic set-up using UR-Script and custom Python modules. Through multiple exercises, students learn how to design and robotically build small-scale spatial structures exhibiting the potential of robotic fabrication processes. Additionally, they employ simple feedback loops for improving the accuracy of the fabrication process and as design-drivers.

MAS in Architecture and Digital Fabrication - Key for Type

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ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## MAS in Architecture, Real Estate, Construction

### Core Courses

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<th>Number</th>
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<td>072-0001-00L</td>
<td>Construction Industry and Real Estate Market</td>
<td>O</td>
<td>3</td>
<td>7G</td>
<td>A. Paulus, S. Menz</td>
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</table>

**Abstract**
In the first term of MAS ETH ARC, the students knowledge of the construction sector and the real estate market will be reinforced and deepened, along for an informed interpretation of the stakeholders' decision making processes. It explores the topics of involved parties and perception of demand. Additionally, it will guide students in developing their research proposals and research questions.

**Objective**
The first term of MAS ETH ARC supports the students' expertise and personal skills and develops their reasoning and creative thinking skills. It compels the students to understand both ambitious projects and complex properties, to pursue long-term intentions, to carry out specific tasks, and to become aware of the consequences of their decisions. Over the course unit, students review and closely examine the expertise which they have gained so far. The course directs students to draw independent conclusions and to set forecasts as professionals. Ultimately, the knowledge and expertise which is gained throughout the unit will allow the students to fully realise their role as a professional in their field.

**Content**
In the first term of MAS ETH ARC, the students knowledge of the construction sector and the real estate market will be reinforced and deepened, along for an informed interpretation of the stakeholders' decision making processes and interests. It also explores the topics of involved parties and perception of demand. Additionally, it will guide students in developing their research proposals and research questions.

Key words of the course unit
Project and property, design and building process, involved parties and services, interests, basic knowledge and terms, perception and dissociation, sustainable decisions, and life cycle

**Lecture notes**
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

**Literature**
Scripts, documents, studies, dates and addresses are stored on the server of the program.

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<td>072-0003-00L</td>
<td>Methodology</td>
<td>O</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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</table>

**Abstract**
In the fourth term of MAS ETH ARC, the students will guide through the process of methodology which is the ability to put their attitude into practice. Additionally, the course unit puts emphasis on the research findings and finalisation of the written work.

**Objective**
The fourth term of MAS ETH ARC supports the students' attitude and practice and methodology. It compels the students to analyse issues and carry out solutions. Ultimately, the knowledge and expertise which is gained throughout the unit will allow the students to fully realise their role as a professional in their field.

**Content**
In the fourth term of MAS ETH ARC, the students will guide through the process of methodology which is the ability to put their attitude into practice. Additionally, the course unit puts emphasis on the research findings and finalisation of the written work.

Key words of the course unit
Objectives, methodology, research, analysis and interpretation, academic writing, text understanding, publishing

**Lecture notes**
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

**Literature**
Scripts, documents, studies, dates and addresses are stored on the server of the program.

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### Major in Digitalisation

#### Core Courses

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<tbody>
<tr>
<td>072-0101-00L</td>
<td>Module 1: Foundations of Digitalisation</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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</tbody>
</table>

**Abstract**
Key terms: Digital transformation is more than digitisation of existing processes and information

**Objective**
Independently of the building industry, Module 1 initially provides information about the characteristics of digitalisation through its principles and rules, enabling the participants to independently recognise the short-term and long-term changes that are resulting from it.

**Content**
The first module addresses the topic of digitalisation and digital transformation in a holistic sense. It is much more than converting documents into PDFs or using software. It is about transforming processes, resources and information into a consistent and efficient digital system to make life easier for employees and customers. This journey always involves change. From the perspective of other industries, we first build up a basic understanding and discuss the opportunities and risks.

How do the experiences of other industries help us? What can be derived from them? Why is BIM only a small part and why is the future of BIM not BIM?

**Lecture notes**
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

**Literature**
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

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<tbody>
<tr>
<td>072-0102-00L</td>
<td>Module 2: Collaboration</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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</tbody>
</table>

**Abstract**
Key terms: "Behave for Collaboration" - Structural questions on collaboration and the patterns of behaviour.

**Objective**
In Module 2, we break from the theoretical idea of a purely technology-based, better collaboration and look at the situation realistically in order to be able to understand and develop new solutions and requirements.

**Content**
The usual approach towards digital transformation is to train people to use new technologies. In contrary, we ask for the specific challenges and problems people have with change. We learn to understand viewpoints of different partners within building projects and new solutions to specific problems.

**Lecture notes**
Scripts, documents, studies, dates and addresses are stored on the server of the program and accessible to students on the Miro Board.

**Literature**
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch
What does it take to be able to work together in a digitally networked environment? How many "techie genes" are needed to work efficiently?

The module offers the opportunity to prepare for the voluntary buildingSMART Professional Certification.

#### Module 4: Foundation of Value Creation

**Objective**

Key terms: Added value of digital transformation, distributed data management, digital twin, logistics and robotics.

**Content**

"Highway to hell or highway to haven" - the question of a clear and simple roadmap is always at the heart of a digital transformation. "Value creation" is a central goal. Digitalisation is often seen as a strategy from the productivity gap. The fourth module shows how strategic goals can be developed in a roadmap and implemented in practice and how the individual shareholders and stakeholders participate.

We learn to consciously look at the topic of added value and digital transformation from different perspectives. Collision checking and quantity take-offs (QTO) are very useful. But they are only basics when it comes to real value creation.

#### Module 5: New Business Modelle

**Objective**

Key terms: Business models, cultural change, disruption, evolution, lean methods

**Content**

As a final module, new business models are discussed and explored. Examples will be used to explore patterns and interfaces and to analyse what is needed today and in the future for a successful and sustainable development of the sector. How can innovative ideas move us forward? What can we learn from design thinking? Why is it important for people to have useful and understandable measurable values? How do the 17 Sustainable Goals influence our industry?

We will analyse the topic on the basis of two concrete examples, familiarise ourselves with them and observe their further development as a result.

#### Term Paper

The **Term Paper** is offered in spring semesters only.

#### Major in Project Leadership

#### Core Courses

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<td>072-0201-00L</td>
<td>Module 1: Understanding of Roles</td>
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<td>Module 2: Collaboration</td>
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<tr>
<td>072-0203-00L</td>
<td>Module 3: Services</td>
<td>W</td>
<td>1</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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</table>

**Lecture notes**

Please find the teaching material, the further readings and Information on our server.

**Literature**

Please find the teaching material, the further readings and Information on our server.

www.map.arch.ethz.ch/en
The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.

- Phases and services
- Due diligence and duty of loyalty
- Duties and tasks, liability
- Working packages
- Management and coordination

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Please find the teaching material, the further readings and Information on our server.

www.map.arch.ethz.ch/en

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### Objective

- Management and administration
- Leadership
- Team performance
- Motivation and conflict resolution

---

### Literature

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Please find the teaching material, the further readings and Information on our server.

www.map.arch.ethz.ch/en

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### Term Paper

The Term Paper is offered in spring semesters only.

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### Major in Real Estate Strategies urban-peri-urban

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### Core Courses

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<td>Module 1: Perception of Demand</td>
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<td>1</td>
<td>2G</td>
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<td></td>
<td>Key words: construction and real estate market, micro and macro environment</td>
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<td>In Module 1, by interpreting the snapshot of one's own enterprise and opportunities and dangers to appreciate.</td>
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<td>Introductory module «Enterprise» considers the role of organizations in the economic network of markets and their identity. It presents the peculiarities of planning offices as a service provider, shows different types of companies and discusses the business cycle from founding to succession planning. In addition, the branch-specific development of leadership and organizational models as well as the problem of access to international markets are examined. Accompanying the basics of a general business model for service companies are taught and key criteria defined.</td>
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<td>Key words: Bauwerk Schweiz, new construction and renovation, economy</td>
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<td>Change in value, demolition / replacement, potential for compression</td>
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<td>With more than CHF 3'585 billion (excluding land), Switzerland is the largest national capital. It grows by around 4.7 per cent each year, but its value is under-invested. Is there a risk of slippage? Should more be invested in maintenance / repair or more canceled and replaced? How big is the compaction potential in the stock? Excursus on civil engineering and infrastructure construction</td>
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<tr>
<td>072-0303-00L</td>
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<td>2G</td>
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<td>Abstract</td>
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<td>Key words: intention development, realization operation</td>
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<td></td>
<td>The participants understand a property in the context of a life cycle</td>
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### Literature

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

Please find the teaching material, the further readings and Information on our server.

www.map.arch.ethz.ch/en
The importance of a life-cycle-oriented approach has arrived in the Swiss construction and real estate sector. Cumulative management costs can exceed the cost of construction after just a few years. In this module, a systematic consideration of the phases and processes in the life cycle of a property takes place. Study I explores various aspects of life-cycle planning and construction.

<table>
<thead>
<tr>
<th>Module 4: Course of Action</th>
<th>W</th>
<th>1 credit</th>
<th>2G</th>
<th>S. Menz</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module 5: Life Cycle and Resources</strong></td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>S. Menz</td>
</tr>
<tr>
<td><strong>Module 3: Marketing</strong></td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
<tr>
<td><strong>Module 2: Acquisition</strong></td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
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<tr>
<td><strong>Module 1: Market</strong></td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>A. Paulus, S. Menz</td>
</tr>
</tbody>
</table>

**Objective**
- The aim is to use a snapshot in time to interpret one's own company and become able to assess opportunities and risks.

**Content**
- The "company" module considers the role of organisations within the economic network of the markets and the nature of their identity. It presents the structural and social aspects of networking and professional dialogue. Both of these tools require interaction: everyone involved is both an addressee and also basically an equal interlocutor. Networking can be learned: situational "small talk," social competence and a healthy ability to communicate can be learned.

**Literature**
- Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch
Abstract
Key terms: Cost accounting, budgeting and controlling

Objective
The aim is to become able to analyse one's own company's financial resources in detail, interpret key parameters for the current situation and test them.

Content
Financial management means achieving the target company output with costs that are as low as possible, and in the longer term to create secure asset and capital structures. The tasks involved in financial management in a planning office include establishing a well-structured accounting department, careful cost accounting, sound budgeting and an effective controlling system. On the basis of a practical financial structure for architecture and engineering offices, the "financial management" module presents the information needed to carry these tasks out in a professional and responsible way.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

072-0405-00L Module 5: Digitalisation
Only for CAS ARC in Unternehmensführung and MAS in Architecture, Real Estate, Construction.

Abstract
Key terms: Strategy, potentials and digital planning

Objective
The aim is to become familiar with the current practical work involved in IT in planning companies and be able both to analyze the specific challenges it implies and also to infer one's own prospects for development in this context. In addition, thought needs to be given to the way in which the value creation provided by digitalisation influences one's own company.

Content
IT refers on the one hand to information and data processing in a company, and on the other to the hardware and software components needed for the purpose. This "information technology" module focuses on potential strategies for company management in the IT field. The focus is not on the use of any individual programme, but on taking conscious decisions for or against IT components in one's own company in order to obtain helpful support in one's everyday work. The strengths, weaknesses, opportunities and risk of this strategy suggest possible potentials.

The participants will present their own theses on entrepreneurship and open them up for discussion in the plenary session.

Lecture notes
Scripts, documents, studies, dates and addresses are stored on the server of the program.

Literature
Literature recommendations at www.bauprozess.arch.ethz.ch and www.kompetenz.arch.ethz.ch

Term Paper
The Term Paper is offered in spring semesters only.
MAS in Preservation and Construction History

Start: Every two years in the autumn semester with an even numbered year
Duration: 4 semesters part time

Field of Preservation

Core Courses and Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>079-0100-00L</td>
<td>Seminar Basics</td>
<td>O</td>
<td>3 credits</td>
<td>2S</td>
<td>S. Langenberg</td>
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<td></td>
<td>Only for CAS in Preservation and MAS in</td>
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<td>Preservation and Construction History</td>
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<td>The seminar provides an introduction to</td>
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<td>the basics of scientific work. It imparts</td>
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<td>methods of architectural and cultural</td>
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<td>studies, introduces participants to</td>
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<td>archive-based research and enables them</td>
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<td>to critically and analytically evaluate</td>
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<td>the sources consulted. Forms of</td>
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<td>communicating scientific results are also</td>
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<td>a topic of the seminar.</td>
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<td>Objective</td>
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<td>The aim of the seminar is to qualify</td>
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<td>participants to apply methods of</td>
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<td>architectural and cultural studies in the</td>
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<td>evaluation of objects of the built</td>
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<td>environment. Participants are enabled to</td>
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<td>assess a building which they have selected</td>
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<td>in the form of a heritage conservation</td>
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<td>report.</td>
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<td>Content</td>
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<td>An essential basis for a responsible</td>
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<td>engagement with the built heritage is the</td>
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<td>ability to recognise its characteristics</td>
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<td>and peculiarities from an architectural</td>
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<td>scientific point of view, and to</td>
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<td>objectively elaborate on them. For this,</td>
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<td>knowledge of scientific methods is just as</td>
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<td>much a prerequisite as the ability to</td>
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<td>undertake purposeful research and to</td>
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<td>critically evaluate source material in</td>
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<td>order to productively include it in the</td>
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<td>analysis. The first part of the seminar</td>
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<td>is devoted to an introduction to scientific</td>
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<td>work in the fields of architectural and</td>
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<td>cultural studies. This lays the foundation</td>
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<td>for the second part, which deals with the</td>
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<td>independent scientific evaluation of a</td>
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<td>building which the participants choose</td>
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| 079-0101-00L| Seminar Texts on Preservation             | O    | 3 credits | 2S    | R. Rehm, S. Langenberg |
|             | Only for CAS in Preservation and MAS in    |      |           |       |                 |
|             | Preservation and Construction History      |      |           |       |                 |
|             | Abstract                                   |      |           |       |                 |
|             | In the seminar, selected texts on         |      |           |       |                 |
|             | architectural theory and monument         |      |           |       |                 |
|             | preservation are read together and         |      |           |       |                 |
|             | discussed in plenary. The focus is on      |      |           |       |                 |
|             | selected writings from John Ruskin, Gottfried Semper and Friedrich Nietzsche to Alois Riegl and Adolf Loos to Walter Benjamin, Aleida Assmann and Peter Zumthor. | | | | |
|             | Objective                                 |      |           |       |                 |
|             | Skills in reading complex theoretical and  |      |           |       |                 |
|             | literary writings on architecture and      |      |           |       |                 |
|             | monument preservation are taught. With    |      |           |       |                 |
|             | increasing practice, these enable         |      |           |       |                 |
|             | participants to undertake an independent   |      |           |       |                 |
|             | appropriation of architectural theory and  |      |           |       |                 |
|             | monument preservation content.            |      |           |       |                 |
|             | Content                                   |      |           |       |                 |
|             | The writings on architectural theory and   |      |           |       |                 |
|             | historic preservation discussed in the     |      |           |       |                 |
|             | seminar provide an overview of the most    |      |           |       |                 |
|             | important theories and concepts of         |      |           |       |                 |
|             | historic preservation. Ruskin's narrative  |      |           |       |                 |
|             | of architectural historicity, Semper's     |      |           |       |                 |
|             | conception of "Bekleidung" and Nietzsche's|      |           |       |                 |
|             | transformation of mythology are covered,   |      |           |       |                 |
|             | as are Riegl's notions of "Erinnerungswert"|      |           |       |                 |
|             | and "Gegenwartswert", Loos' writings on    |      |           |       |                 |
|             | architecture, Benjamin's notion of aura    |      |           |       |                 |
|             | and Aleida Assmann's memory space as well  |      |           |       |                 |
|             | as Peter Zumthor's atmosphere. Each text   |      |           |       |                 |
|             | is discussed in terms of textual structure,|      |           |       |                 |
|             | conceptual history, visual language,       |      |           |       |                 |
|             | relationship to poetry and literature,     |      |           |       |                 |
|             | strategies of theory, etc. Identifying the |      |           |       |                 |
|             | levels and intersections that link a      |      |           |       |                 |
|             | theory with other theories characterises   |      |           |       |                 |
|             | one of the main tasks of our seminar.      |      |           |       |                 |

| 063-0911-22L| Future Monuments                           | O    | 2 credits | 2V    | S. Langenberg   |
|             | Only for CAS in Preservation and MAS in    |      |           |       |                 |
|             | Preservation and Construction History      |      |           |       |                 |
|             | Abstract                                   |      |           |       |                 |
|             | Heritage conservation is dedicated to the  |      |           |       |                 |
|             | preservation and protection of historical  |      |           |       |                 |
|             | buildings. In this lecture, students will  |      |           |       |                 |
|             | learn about the theoretical positions on   |      |           |       |                 |
|             | historic monuments and the basics of       |      |           |       |                 |
|             | preservation in practice.                  |      |           |       |                 |
|             | Objective                                 |      |           |       |                 |
|             | In addition to active participation in the  |      |           |       |                 |
|             | discussions, students will be asked to     |      |           |       |                 |
|             | engage with a topic or object of their     |      |           |       |                 |
|             | own choice in order to be able to develop  |      |           |       |                 |
|             | and comprehensively justify their own       |      |           |       |                 |
|             | positions within the context of             |      |           |       |                 |
|             | preservation. Our goal here is to          |      |           |       |                 |
|             | foster students' communication skills and  |      |           |       |                 |
|             | the culture of discussion.                 |      |           |       |                 |
|             | Content                                   |      |           |       |                 |
|             | The responsible reconstruction and further  |      |           |       |                 |
|             | development of the existing building stock |      |           |       |                 |
|             | requires knowledge and an understanding of  |      |           |       |                 |
|             | the theoretical positions conservation and  |      |           |       |                 |
|             | the basics of preservation in practice.    |      |           |       |                 |
|             | This core conveys this knowledge to students|      |           |       |                 |
|             | with the help of selected writings and     |      |           |       |                 |
|             | discusses them in the context of various   |      |           |       |                 |
|             | guest lectures. In addition to dealing with |      |           |       |                 |
|             | historical buildings, the course is also    |      |           |       |                 |
|             | dedicated to younger (and very young)      |      |           |       |                 |
|             | objects and inventories - for in addition  |      |           |       |                 |
|             | to the preservation of already listed      |      |           |       |                 |
|             | objects, the selection and                 |      |           |       |                 |
|             | inventorisation of future protected       |      |           |       |                 |
|             | objects is also one of the core tasks of   |      |           |       |                 |
|             | heritage conservation.                     |      |           |       |                 |
Monographs and edited volumes:


- Dehio, Georg, Kunsthistorische Aufsätze. München 1914


- Franz, Birgit, Gerhard Vinken and Johanna Blokker (Hg.), Denkmal - Werte - Bewertung. Denkmalpflege im Spannungsfeld von Fachinstitution und bürgerschaftlichem Engagement, Holzminden 2013 (Veröffentlichung des Arbeitskreises Theorie und Lehre der Denkmalpflege e.V., Band 23).


- ICOMOS Deutschland/ Österreich/ Luxemburg/ Schweiz (Hg.), Monumenta I: Internationale Grundsätze und Richtlinien der Denkmalpflege, Stuttgart 2012.


- Petzet, Michael and Gert Mader (Hg.), Praktische Denkmalpflege. Stuttgart/ Berlin/ Köln 1993.


- Schmidt, Leo (Hg.), Einführung in die Denkmalpflege, Darmstadt 2008.


- Wohlleben, Marion and Georg Mörsch, Georg Dehio und Alois Riegl - Konservieren, nicht restaurieren. Streitschriften zur Denkmalpflege um 1900, Basel 1988 (Bauwelt Fundamente 80)

- Hassler, Uta, Langfriststabilität. Beiträge zur langfristigen Dynamik der gebauten Umwelt, Zürich 2011

Fundamentals and legal texts:

- Stadt Zürich Hochbaudepartement, Amt für Städtebau, Denkmalpflege und Archäologie (Hg.), Schulhäuser der Stadt Zürich. Spezialinventar Archäologie und Denkmalpflege, September 2008

- Stadt Zürich Hochbaudepartement, Amt für Städtebau (Hg.), Bauten, Gärten und Anlagen 1960 bis 1980. Inventarergänzung, August 2013


- Denkmalpflegegesetzgebung in den Heimatkantonen der Kursteilnehmenden.

- Die Kunstdenkmäler der Schweiz

- INSA – Inventare der Heimatkantonen der Teilnehmenden
In order to get to know the formation of theory, its paths and detours, the most important terms and persons in the history of monument preservation, S. Langenberg assessed the course provides an overview of theory formation in heritage conservation. The focus is on European history and German-language literature. The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation. The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a "monument", structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with the procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer's (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.

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### ▶▶ Major Courses and Cooperations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>079-0150-00L</td>
<td>Preservation Law</td>
<td>O</td>
<td>2</td>
<td>1G</td>
<td>S. Langenberg</td>
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<td></td>
<td>Only for CAS in Preservation and MAS in Preservation and Construction History</td>
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<tr>
<td>Abstract</td>
<td>The course elaborates the legal concept of “monument” in its important distinction from the respective scientific concept. It highlights its embeddedness and effect in public building law. Furthermore, it deals with legal protection instruments and procedures.</td>
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<tr>
<td>Objective</td>
<td>In addition to elaborating the legal concept of monuments, the course familiarises participants with legal protection instruments and procedures. It is planned to involve the participants by means of practical examples.</td>
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<tr>
<td>Content</td>
<td>The first part is devoted to substantive preservation law: legal foundations and qualification of an object as a &quot;monument&quot;, structural-legal aesthetics and architectural monument, scope of protection as well as prerequisites for protection. The second part deals with the procedures: Responsibilities of the various authorities/bodies, record of objects, provisional and definitive protection (in particular according to the protection objective and effect of the various protection instruments) and appellate proceedings. In accordance with the lecturer's (Dr. Dominik Bachmann) practical experience, formal preservation law is based on Zurich law, the principles of which, however, also apply in the monument preservation ordinances of the other cantons, which differ in detail. These are referred to selectively and by way of example.</td>
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<tbody>
<tr>
<td>079-0151-00L</td>
<td>Theory and History of Preservation in the German-speaking Realm</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>external organisers</td>
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<td></td>
<td>Only for CAS in Preservation and MAS in Preservation and Construction History</td>
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<tr>
<td>Abstract</td>
<td>The course provides an overview of theory formation in heritage conservation. The focus is on European history and German-language literature.</td>
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<tr>
<td>Objective</td>
<td>The aim of the course is to familiarise students with the essential subject areas, the most important protagonists and lines of argumentation from antiquity to the 21st century, and to contrast the different approaches to thought and their development</td>
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<tr>
<td>Content</td>
<td>In order to get to know the formation of theory, its paths and detours, the most important terms and persons in the history of monument conservation are introduced. Based on various texts, the history of the protection of architectural monuments since antiquity is illuminated. Further focal points in the history of monument preservation were during the Enlightenment, the French Revolution and in the process of the formation of nation states. The discourse on the concept and practice of monument conservation as we understand it today was led by a number of conservators in the German-speaking world around 1900. War-related destruction and the incipient building boom in Europe led to modern debates on the theory of monuments, which are still relevant today. Dealing with monument values is not an end in itself; it can be essential for the preservation of the monument or for historical mediation. Critical positions on the tasks, goals or practices of heritage preservation can only be developed against the background of a knowledge of its historical approaches.</td>
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### Literature

- Leo Schmidt, Einführung in die Denkmalpflege, Darmstadt 2008.
- Wolfgang Götz, Beiträge zur Vorgeschichte der Denkmalpflege. Die Entwicklung der Denkmalpflege in Deutschland vor 1800 (Diss. Leipzig 1956), Zurich 1999 (Veröffentlichungen des Instituts für Denkmalpflege an der ETH Zürich, vol. 20).
- Gottfried Kiesow, Einführung in die Denkmalpflege, Darmstadt 1982.
- Wolfgang Götz, Beiträge zur Vorgeschichte der Denkmalpflege. Die Entwicklung der Denkmalpflege in Deutschland vor 1800 (Diss. Leipzig 1956), Zurich 1999 (Veröffentlichungen des Instituts für Denkmalpflege an der ETH Zürich, vol. 20).

### Prerequisites / notice

To follow additional courses and seminars.
This lecture series deals with the history of the production of buildings. This history draws heavily on pictorial and archival sources, but the lecture will always establish the link to traces observable on site. In that sense, the lecture is an introduction to the wide topic of "building archeology". Among others, we will cover the following topics:

- construction materials, tools and tooling of construction elements
- material flow and economic boundary conditions of the construction site
- construction site technology and construction machinery (scaffolding, cranes, etc.)
- historic methods of architectural planning
- history of building production

This lecture is closely related to current research projects.

Lecture notes
PDFs of the lecture slides will be provided before the lecture. Furthermore, the audience will be granted access to recent journal articles and book chapters providing in-depth insight into the topics covered by the lecture.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

► Additional Major Courses and Cooperations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>052-0913-22L</td>
<td>Preservation: A Future for whose Past?</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>S. Langenberg</td>
</tr>
</tbody>
</table>

Number of participants limited to 40.

ITA Pool Introduction to courses within the institute ITA:
7.9.22, 10-11h. HIB Open Space.

Abstract
A Future for Whose Past? The focus is on the heritage of minorities, marginalised groups and people without a lobby. This rarely considered heritage will be explored theoretically and practically through excursions, meetings and readings. The aim is to develop a concept and mediation formats for an international exhibition in 2025, the 50th anniversary year of the European Heritage Year 1975.

Objective
The students gain insight into the most important theories and practices of monument preservation and ways of conveying and exhibiting them. Through the examination of a self-selected topic, questions can be deepened and discussed in the group. The learning objectives in this semester are critical questioning of heritage and inventory, strengthening of mediation skills and the consideration of architecture and urban development in cultural-historical, sociological and economic perspectives.

Content
In monument preservation, too, the existence of a "mainstream" and a lack of inclusion have been criticised. This is particularly visible in the post-colonial UNESCO World Heritage status of 1,154 sites, of which only about a hundred are in Africa, but almost 600 are in Europe. But at the national level, too, there is a need to discuss whether the sites protected by monument, nature and heritage conservation laws in the German-speaking and thus preserved for the future actually represent history and the past. Whose heritage are we talking about, who determines what is important for society's memory and with which heritage a society identifies?

In the autumn semester of 2022, we will devote ourselves to the heterogeneity of the architectural heritage and critical approaches to monument preservation. Innovative methods and interfaces of public mediation will be investigated and applied. The insights gained will flow into the conception and development of the exhibition.

Literature


Gender and Heritage. Performance, Place and Politics, ed. by Wera Grahn and Ross J. Wilson, London/New York 2018
The elective subject “Methods of Building Surveying” covers surveying and measurement methods ranging from simple hand measurements and tachymetry to laser scanning, terrestrial and drone-based photogrammetry (structure from motion) and other non-invasive assessment methods such as thermal imaging. The different methods and technologies will be presented on the basis of current or completed research projects and their practical applications will be discussed. Internal and external guest speakers will report on their latest research projects in the field of building research and construction history. In the course of the elective, students will also have the opportunity to try out the methods themselves and integrate them into a small concluding project of their own.

The course is composed of theoretical and practical parts in and outside the classroom. Will be announced in the course for the individual lectures.

<p>| Electives |
|-----------|-----------------|-----------------|-----------------|-----------------|</p>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>052-0705-00L</td>
<td>Landscape Architecture I</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>C. Girot</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the history and theory of garden design and landscape architecture. Analysis of the design of historical gardens and landscapes within the cultural background.

Objective
The course covers the basic history and theory of garden design and landscape architecture from its beginnings to the 21st century. The course aims to raise awareness of a changing perception of nature and landscape.

Content
The lecture series on History and Theory of Garden Design and Landscape Architecture deals with the historical development of designed nature, from the beginnings of cultural landscapes and gardens to 21st century landscape architecture. In the analysis of each era, the focus is on the spatial and cultural relationship between the garden, the city and the landscape, as well as the changing perceptions of nature and its representation.

Lecture notes
Handouts and a reading list will be provided.

Literature
A reading list will be provided for the exams.
General Information for the final exam:
Bachelor students: The content of the lectures as well as texts and exam-relevant literature provided by the Chair make up the basis for preparing for the exam. The lecture series is conceived as a yearlong course. Since the written session examination will test knowledge from both semesters, it is necessary to fully attend the lectures of both courses “Landscape Architecture I” and “Landscape Architecture II”. The themes of the examination will be announced at the end of the semester. The Chair will provide literature and texts available for download as pdfs. These allow a more in-depth understanding of the lecture material.
Exchange students or students from other departments: Students, who are attending only one semester, may pass the oral end-of-semester examination. Test-relevant literature will also be made available for download for this purpose. The students are requested to get in touch by email with the Chair.

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>2 credits</th>
<th>2V</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>052-0901-00L</td>
<td>Building History I</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>S. Holzer</td>
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</tbody>
</table>

**Abstract**
History of building from classical antiquity to modernity: building types, constructions, forms, with particular reference to functional issues such as flexibility of use, statics, durability. This is not a mere history lecture, but an important part of the basic introduction into construction.

**Objective**
Participants know the fundamentals of building history, including landmark monuments of each era, key historic constructions and forms. They are able to "read" a historic building and to relate it to building history. They are aware of the variety of historic building constructions.

**Content**
Building history I covers the period from classical Greek antiquity to Gothic architecture. The principal topics include construction issues such as Greek megalithic building, Roman mortar-and-rubble construction, and Gothic rationalism of vaulted architecture.

Within the Vitruvian and Albertian triad of firmitas, utilitas and venustas, we focus on the first two topics, whereas the last topic (deciphering the "meaning" of architecture) stands at the heart of the "architectural history" lectures. The present lecture contributes essentially to deepening knowledge about historic constructions, an indispensable precondition for building within existing fabric.

**Lecture notes**
Please keep a tight record of manuscript notes yourself. Lecture notes to some topics will be provided. pdf of lecture slides will be on line before each lecture.

**Literature**
Will be announced during the lectures.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Competencies</th>
<th>Assessed</th>
<th>Not Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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**MAS in Preservation and Construction History - Key for Type**

<table>
<thead>
<tr>
<th>Key Code</th>
<th>Type Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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**Key for Hours**

<table>
<thead>
<tr>
<th>Key Code</th>
<th>Type Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Digital Clinical Research

Mandatory Modules

Module Modern Concepts in Clinical Research

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>395-0100-00L</td>
<td>From Clinical Problem to Research Question</td>
<td>O</td>
<td>1.5 credits</td>
<td>2G</td>
<td>S. Goldhahn, A. Frotzler, J. Steurer</td>
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<tr>
<td></td>
<td>Only for CAS in Modern Concepts in Clinical Research and MAS in digital Clinical Research</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td></td>
<td>The course will discuss how to design a clinical study and addresses topics such as the quantification of medical need, the reduction of unnecessary complexity, and the identification of clinical outcome measures.</td>
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<td>Objective</td>
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<td>After taking this course, participants will be able</td>
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<tr>
<td></td>
<td>- to read a clinical study publication in a structured way;</td>
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<td>- to apply analytical schemes to appraise a clinical study;</td>
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<td>- to explain why the participants of a study are randomized, to know methods how to randomize and to understand the consequences of randomization for the conduct of the study;</td>
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<td>- to understand how to deal with AE / SAE and how to report them;</td>
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<td></td>
<td>- to describe and explain clinical outcomes, to differentiate between different outcomes, to explain important aspects of cross-cultural use of patient-reported outcomes and basic psychometric properties.</td>
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<tr>
<td>395-0101-00L</td>
<td>Modern Study Concepts</td>
<td>O</td>
<td>1.5 credits</td>
<td>1G</td>
<td>A. Burden, S. Goldhahn, further lecturers</td>
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<td></td>
<td>Only for CAS in Modern Concepts in Clinical Research and MAS in digital Clinical Research</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>In the course, participants are introduced to established study designs and study elements, as well as to modern study concepts and observational designs to address clinical questions. Another focus is on patient perspectives and patient preference studies.</td>
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<td></td>
<td>Objective</td>
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<td></td>
<td>After taking this course, participants will be able</td>
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<tr>
<td></td>
<td>- to identify and describe the most common study designs in observational Phase IV drug safety research;</td>
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<td></td>
<td>- to discuss the strengths and limitations of each design;</td>
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<td>- to differentiate between different types of real-world healthcare databases, and explain the key differences between different databases that are important when selecting the right data for a research question;</td>
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<td>- to identify and describe advanced study designs in observational research;</td>
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<td>- to explain the advantages and disadvantages of these designs, and to identify what research questions are most suited to the advanced research questions;</td>
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<td>- to identify and overcome different sources of bias;</td>
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<td>- to describe the difference between including versus involving patient and family stakeholders in research studies</td>
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<td></td>
<td>Identify ways to involve patient stakeholders into research.</td>
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<tr>
<td>395-0102-00L</td>
<td>Real-World Data</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>K. Cramer, C. Jutzele, S. Österle</td>
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<td>Only for CAS in Modern Concepts in Clinical Research and MAS in digital Clinical Research</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>The course provides an overview of the importance of Real-World Data (RWD), different RWD sources, and how RWD can be exploited in healthcare, clinical and personalised health research, as well as in regulatory decision making. It highlights current trends and existing methods for using and analysing RWD.</td>
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<td></td>
<td>Objective</td>
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<td>After the course, participants will be able to</td>
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<tr>
<td></td>
<td>1. describe the role and relevance of RWD in the context of healthcare and research; illustrate how RWD are used in regulatory decision making; explain the difference between RWD and clinical trials data.</td>
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<td>2. explain the challenges of RWD providing specific examples; illustrate how data presentation and quality affects the gathering and usage of RWD in research; characterize different data models; describe the governance challenges associated with RWD and outline possible solutions.</td>
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<td>3. describe different sources of RWD in Switzerland; explain common challenges when accessing and using RWD; illustrate how other countries managed and mitigated these challenges.</td>
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<td>4. understand data contents and target population coverage; apply the gained knowledge to a RWD dataset.</td>
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<td>5. demonstrate how one can use RWD for a prediction task; describe how RWD can aid diagnosis; describe how RWD can be used to inform the design and implementation of clinical trials.</td>
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<td>6. explain how bias and confounding in RWD can be assessed; discuss methods to deal with bias and confounding in RWD; discuss the impact bias and confounding can have on the interpretability of the results derived from RWD.</td>
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<td>7. practice the use of CSV, RDF, and SPARQL; illustrate the data structures and elements.</td>
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<td>8. describe how data sources can be pooled or merged; discuss the advantages of pooling data; explain the challenges and pitfalls of pooling data; explain how to address these challenges and pitfalls from a methodological point of view.</td>
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<td>9. apply knowledge gained in the first part of the course to real-world data; present the results: population structure, assessment of bias and confounding; conduct a prediction task on a data set.</td>
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<tr>
<td>395-0103-00L</td>
<td>Precision Medicine</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>S. Modica, A. Ghosh, C. Wolfrum</td>
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<tr>
<td></td>
<td>Only for CAS in Modern Concepts in Clinical Research and MAS in digital Clinical Research</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Precision Medicine is a new approach in health care aiming to deliver personalized prevention and treatment for human diseases, by taking into account individual differences in lifestyle, environment, and biology.</td>
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<td>Objective</td>
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<td></td>
<td>After taking this course, participants will be able</td>
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<tr>
<td></td>
<td>- to describe the goal of precision medicine;</td>
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<td>- to explain different next-generation sequencing technologies;</td>
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<td>- to illustrate how to make good use of public biological/clinical repositories;</td>
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<td>- to demonstrate basic concepts of big data and machine learning;</td>
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<td>- to explain how to genotype biological samples for a genetic disease;</td>
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<td>- to describe examples of complicated ethical or clinical situations in personalized medicine.</td>
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Compulsory Elective Modules
## Module Regulatory Thinking

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<tbody>
<tr>
<td>395-0200-00L</td>
<td>Introduction Regulatory World</td>
<td>W</td>
<td>1 credit</td>
<td>2G</td>
<td>to be announced</td>
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<tr>
<td></td>
<td>Does not take place this semester.</td>
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<td>Only for CAS in Regulatory Thinking and MAS in digital Clinical Research</td>
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<tr>
<td>395-0201-00L</td>
<td>Regulatory Thinking</td>
<td>W</td>
<td>3 credits</td>
<td>4G</td>
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<td>Does not take place this semester.</td>
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<td>Only for CAS in Regulatory Thinking and MAS in digital Clinical Research</td>
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<tr>
<td>395-0202-00L</td>
<td>Intended Use / Indication</td>
<td>W</td>
<td>2 credits</td>
<td>1G</td>
<td>to be announced</td>
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<td>Does not take place this semester.</td>
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<tr>
<td></td>
<td>Only for CAS in Regulatory Thinking and MAS in digital Clinical Research</td>
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<tr>
<td>395-0203-00L</td>
<td>Production / GMP</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>to be announced</td>
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<td>Does not take place this semester.</td>
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<tr>
<td></td>
<td>Only for CAS in Regulatory Thinking and MAS in digital Clinical Research</td>
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## Module Nutrition in Medicine

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tr>
<td>395-0300-00L</td>
<td>Introduction to Nutrition</td>
<td>W</td>
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<td>1G</td>
<td>F. von Meyenn</td>
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<td>395-0301-00L</td>
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<td>395-0302-00L</td>
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### Master's Thesis

Wird ab HS 2023 angeboten

MAS in Digital Clinical Research - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
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<tr>
<td>Z</td>
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Key for Hours

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<tr>
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<td>U</td>
<td>exercise</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The course is designed to increase awareness of how cultural perceptions and power structures have influenced society and our understanding of and practice in aid. It promotes alternatives to aid as linear and progressive Eurocentric narrative. The course draws on different theoretical perspectives and scrutinizes practical examples of aid interventions and similar initiatives.

Registration only through the NADEL administration office.

Objective
- The course aims at strengthening the capacity in portfolio management for VET, skills development and active labor market policies. It deals with basic issues and challenges of Vocational Education and Training (VET) in Developing Countries. In view of the many of school leavers VET has to place itself between the contradicting intensions of quality education and short-term training interventions.

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariate.

865-0065-00L VET between Poverty Alleviation and Economic Development

Objective
ETH doctoral students working on topics related to poverty reduction in low- and middle income countries may also be admitted.

Registration only through the NADEL administration office.

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariate.

865-0064-00L Decolonizing Aid

Abstract
The course goes beyond awareness raising of personal cultural characteristics and recognizing cultural values within development cooperation. It unfolds traces of colonialism and power structures in day to day live and the aid industry. It promotes searching and initiating alternatives to aid as Eurocentric narrative. Participants get familiar with different theoretical perspectives on decoloniality and scrutinize practical examples of aid interventions and similar initiatives.

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL. Electronic registration may be done only after registration with NADEL secretariate.

865-0070-00L The Private Sector and Development Organizations: Building Successful Alliances

Abstract
The following topics will be discussed: The political economy of the Corporate Social Responsibility discourse, voluntary governance regimes and development: theory of change and effectiveness of soft law approaches, PPPs: introducing concepts and taking stock of experience, analysis of private sector strategies from selected governance actors, engaging with the private sector.

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL.

865-0021-00L Fraud and Corruption: Prevent, Detect, Investigate, Sanction

Abstract
This course seeks to increase the participants' understanding of the multifaceted and dialectic relationships between civil society, governments and private sector. It equips participants with knowledge and tools required for a strategic interaction between private sector organizations and development agencies. The course enables participants to contribute effectively to policy debates on the role of private sector actors and development.

Prerequisites / notice
Students of the course must fulfill requirements specified on the homepage of NADEL.
### Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
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<td>O</td>
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<td>3G</td>
<td>K. Harttgen, I. Günther</td>
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<tr>
<td>865-0007-00L</td>
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<td>O</td>
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<td>865-0010-00L</td>
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<td>O</td>
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<td>2G</td>
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<tr>
<td>865-0010-01L</td>
<td>Environment, Natural Resources and Climate Change</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>J. Neve</td>
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### Abstract

**Development Economics**

This course is an introduction to theoretical and empirical discussions on economic development, with a focus on the challenges of developing countries over the last 50 years. The course provides answers to the following questions: How can and should development be measured? What factors drive economic growth and contribute to poverty reduction?

**History and Forms of International Development Cooperation**

This course presents the origins and evolution of the International Development Cooperation during the last six decades and relates the changing paradigms to their political and socio-economic contexts. It looks at the different actors with their specific roles, approaches and challenges from a Swiss as well as a global perspective.

**Politics and Governance**

The course focuses on selected issues of governance systems in developing countries, and on possible interventions of development cooperation to improve the quality of governance.

**Environment, Natural Resources and Climate Change**

Degradation of the environment and non-sustainable use of natural resources, including land, water, forests and biodiversity is threatening individual livelihoods as well as local, national and international economies. This lecture series will address conflicts related to unsustainable resource use and discuss trade-offs between environmental sustainability and economic development.

### Objective

- **History and Forms of International Development Cooperation**: The student will be able to...
  - analyse the evolution of the International Development Cooperation, selected development theories and their practical application in the historic context
  - describe the Swiss landscape of actors in Development Cooperation and its integration into the international community of donors.
  - assess possible implications of the Agenda 2030 for the structure and practice of the international cooperation

- **Politics and Governance**: The student will be able to...
  - describe the current status and threats of natural resource use and environmental degradation
  - portray the management of natural resources such as land, forest, water, and biodiversity in different contexts and discuss the key challenges in each sector
  - examine the implications of climate change on development and the sustainable management of natural resources
  - analyze conflicts and trade-offs between natural resource use and economic development
  - discuss the global priorities relating to human-induced changes to the environment, and how these can be met

- **Environment, Natural Resources and Climate Change**: The student will be able to...
  - discuss the current status and threats of natural resource use and environmental degradation
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  - analyze conflicts and trade-offs between natural resource use and economic development
  - discuss the global priorities relating to human-induced changes to the environment, and how these can be met

### Content

- **Development Economics**: Measurement of development, poverty and inequality, growth theories, trade and development, education, health, population and development, states and institutions, economic policies for economic growth and poverty reduction, economics of development aid.
Objective

The students will be able to
- consider which social, cultural and psychological factors influence human action, and discuss their importance for development cooperation
- explain different conceptions of development in Western and non-Western cultures and indicate possible consequences for development projects
- display basic knowledge of selected topics on social and cultural development

Content

Raising awareness on selected cultural and social aspects of development issues and their relevance for development cooperation (DC):
- Importance of the concept of "culture" in DC
- Colonialism, decolonization and its consequences
- Promotion of education systems
- Role of religion in development interventions
- Migration - challenges and opportunities
- Cross-cutting issues in DC: gender and disability
- Art and peacebuilding

Objective

The course provides an overview of the links among sanitation, water supply, waste management and environmental and health aspects. It
- gives an understanding of the specific challenges and possible solutions in ensuring environmental services and illustrates their impact on the population and settlements.
- The participants are able to
  - present the global situation and development trends in the sector of sanitation, water supply, waste management and for its main actors;
  - discuss the relationships between water supply, sanitation and health;
  - explain the principles of technologies for drinking water treatment, the management of sewage and waste, as well as appraise their strengths and weaknesses;
  - explain which sustainable concepts are implemented and how they can be inserted into the technical, institutional and social structures so that they are economically, ecologically and socially sustainable;
  - provide information where good professional resources are available.

Objective

The course discusses ethical questions of development relevant for international cooperation. Examples include: possibilities and limits of normative justification of development aid; theories of justice, human rights and the 'rights-based' approach to development, epistemological foundations of development theories, ethical questions of globalization.

Objective

What is justice and why are human rights valid? What is development and what is the responsibility of the State? The answers always include normative judgements. Where these normative dimensions remain implicit, international development cooperation risks the
- provide information where good professional resources are available.

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- provide information where good professional resources are available.
Abstract
This course introduces students to key methods for quantitative policy impact evaluation and covers the different stages of the research process. Acquired skills are applied in a self-selected project applying experimental methods. Students also learn how to perform simple statistical analyses with the statistical software R.

Objective
Students
- know strategies to test causal hypotheses using experimental methods and regression analysis.
- are able to formulate and implement a research design for a particular policy question and a particular type of data.
- are able to critically read and assess published studies on policy evaluation.
- are able to use the statistical software R for data analysis.
- can apply all the steps involved in a policy impact evaluation.

Content
Policy impact evaluation employs a wide variety of research methods, such as statistical analysis of secondary data, surveys or laboratory and field experiments. The course will begin with an overview of the various methodological approaches, including their advantages and disadvantages and the conditions under which their use is appropriate. It will continue with a discussion of the different stages of a policy impact evaluation, including hypothesis generation, formulating a research design, measurement, sampling, data collection and data analysis. For data analysis, linear regression models will be revised, with a focus on difference-in-difference methods, regression discontinuity design and randomized controlled trials used for policy evaluation. Students, who already have a solid background in these methods can skip these sessions.

Throughout the course, students will work on a self-selected project on a suitable topic. In addition, students will have to solve bi-weekly assignments.

Semester Thesis

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<tr>
<th>Number</th>
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<td>4 credits</td>
<td>9A</td>
<td>Lecturers</td>
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Only for MAS in Development and Cooperation.

Abstract
The students work on a question in multidisciplinary groups applying theory-based approaches and sound methods. The results are discussed with experts and policymakers.

The thesis is a literature study with a strong application-oriented or empirical character based on scientific publications, expert opinions and reports from organizations. The work may also include limited information surveys.

Objective
- Practice scientific collaboration in a multidisciplinary team
- Apply themselves to a development topic in order to address policy relevant questions
- Present and discuss study results and policy implications in front of different audiences

MAS in Development and Cooperation - Key for Type

| O | Compulsory               | E- | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z  | Courses outside the curriculum |
| W | Eligible for credits   | Dr | Suitable for doctorate |

Key for Hours

| V | lecture     | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise    | D | diploma thesis |
| S | seminar     | R | revision course / private study |
| K | colloquium  |   |                             |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Handouts for each lecture will be uploaded to Moodle every week. The cooking and laboratory methods will be described in a "script" which will be made available before the start of the course. All lectures will have full notes and a recording made available via Moodle.

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Handouts for each lecture will be uploaded to Moodle every week. The cooking and laboratory methods will be described in a "script" which will be made available before the start of the course. All lectures will have full notes and a recording made available via Moodle.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1480 of 2416
To understand the potential effects of nutrition on exercise performance, with a focus on concepts and principles of nutrition before, during
and after exercise.

### Course Content

- **Concepts and Theories**
  - The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

- **Nutrition and Performance**
  - The course features both didactic presentations and in-class practical exercises including topics such as study design, statistical analysis, scientific writing and communicating results. Preparation of a research proposal will consolidate student learning.

### Prerequisites

- General knowledge about nutrition, human biology, physiology and biochemistry is a prerequisite for this course.

### Performance Assessment

- Students will work in groups, and will assess one group per meal.

- Performance will be assessed by means of:
  1. Contribution to laboratory practical work (30.01.2023 - 8.02.2023);
  2. A written test on course content (via Moodle, completed by 10.02.2023);
  3. A 15 min oral presentation of laboratory results in a seminar with colloquium (active discussion) (17.02.2023);

### Literature

- To be provided by the individual lecturers, at their discretion.

### Prerequisites / Electives

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<th>Number</th>
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<th>Type</th>
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<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease</td>
<td>W</td>
<td>3</td>
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<td>M. B. Zimmermann</td>
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<td>752-6403-00L</td>
<td>Nutrition and Performance</td>
<td>W+</td>
<td>2</td>
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<tr>
<td>766-6304-00L</td>
<td>Introduction to the Nutrition Research Process</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>M. Siegrist, F. Michel</td>
</tr>
</tbody>
</table>

### Lecture Notes

- Lecture notes will be available on the ETH website (moodle).

### Prerequisites

- There are no prerequisites to attend this course, however, students must be available to attend on all days of the course, including the oral presentation and colloquium. Attendance is compulsory.

- Students will work in groups, and will assess one group per meal.

### Performance Assessment

- Performance will be assessed by means of:
  1. Contribution to laboratory practical work (30.01.2023 - 8.02.2023);
  2. A written test on course content (via Moodle, completed by 10.02.2023);
  3. A 15 min oral presentation of laboratory results in a seminar with colloquium (active discussion) (17.02.2023);

### Personal Competencies

- Proficiency in retrieval and interpretation of scientific literature
- Skills in scientific writing and an understanding of the publication process
- Ability to report scientific results in writing and orally
- Proficiency in retrieval and interpretation of scientific literature

### Subject-specific Competencies

- Familiarity with the research process and methods used in human nutrition
- Understanding of basic statistics and analytical skills used in preparing and reporting research, including in tables and graphs
- Ability to report scientific results in writing and orally
- Skills in scientific writing and an understanding of the publication process

### Method-specific Competencies

- Understanding of experimental study design in basic and clinical research
- Familiarity with the research process and methods used in human nutrition
- Understanding of basic statistics and analytical skills used in preparing and reporting research, including in tables and graphs
- Ability to report scientific results in writing and orally
- Skills in scientific writing and an understanding of the publication process

### Literature

- The teaching slides used in the lectures will be made available weekly on Moodle before each class, as pdf files.

- There is no recommended textbook or prior reading required for this class. Students will be provided with recommendations for further reading where relevant, with the lecture notes.

- Students are expected to attend and actively participate in the course, which includes the preparation of a research protocol that will be presented and graded during a poster presentation at the end of the semester.

### References

- M. B. Zimmermann
- D. M. Siegrist
- F. Michel

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**Autumn Semester 2022**

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1481 of 2416
<table>
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<td>3</td>
<td>Winter</td>
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<td>752-5111-00L</td>
<td>Gene Technology in Foods</td>
<td>3</td>
<td>Winter</td>
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<tr>
<td>551-0317-00L</td>
<td>Immunology I</td>
<td>3</td>
<td>Winter</td>
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**Objective**

- Knowledge of the principles and the structure of the EU in general and in the area of food safety, overview of the relevant bilateral agreements CH-EU as well as on the most important international organisations (Codex Alimentarius and WTO) and their influence on the Swiss regulations on food safety.
- Knowledge of the structure of Swiss food legislation and the most important regulations of the Swiss food law. The general principles, institutions and execution of the Swiss food law as well as the implementation of food law in the context of self-supervision are known.
- Analytical data and premises and their equipment can be judged in the legal context of food law.

**Content**

- General introduction into the EU and in the area of food safety (regulation on food safety), legislative procedures in the EU, introduction into the relevant bilateral agreements CH-EU, introduction into international organisations (e.g. Codex Alimentarius), general principles of the Swiss food law and the most important regulations as well as the most important legal procedures, legal settlement and the duties and responsibilities of the Food control authorities.

**Lecture notes**

- Copies of the presentations will be handed out.

**Literature**

- Documents about Codex Alimentarius, the EU regulation as well as the Swiss food law and some regulations will be handed out.

**Prerequisites / notice**

- The lecture will be held in German.

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**Objective**

- To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

**Content**

- This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:
  - Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
  - Protective Cures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
  - Legal and protection issues related to functional foods
  - Industrial biotechnology of flavor and taste development
  - Safety of food cultures and probiotics

**Lecture notes**

- Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

**Prerequisites / notice**

- This lecture requires strong basics in microbiology.

---

**Objective**

- This course will increase basic knowledge on biotechnological constructions and application of genetically modified organisms (GMO) which are used worldwide in food production systems. The course discusses health issues, the legislation frame and food safety aspects of GMO applications in agriculture, food production and consumption in Switzerland and EU-countries.

**Content**

- This course will provide knowledge and biological background on genetically modified organisms (GMO) and food produced with the help of GMO, especially on the molecular basis of GMO constructions with emphasis on genetically modified food in Switzerland and the EU.
- Criteria of rationale food safety and health assessment in agriculture and food consumption will be elaborated.
- Overview on application in gene technology, the gene transfer potential of bacteria, plants and other organisms and the mostly used transgenes in food as well as on GMO used for food production and their detection technologies in food; food safety assessment of GMO food; information on the legislation in Switzerland and EU-countries

**Literature**

- A list of topics for group projects will be supplied, with key references for each topic.

**Prerequisites / notice**

- This lecture requires strong basics in microbiology.

---

**Objective**

- Introduction into structural and functional aspects of the immune system.
- Basic knowledge of the mechanisms and the regulation of an immune response.

**Content**

- Introduction into structural and functional aspects of the immune system.
- Basic knowledge of the mechanisms and the regulation of an immune response.
  - Introduction and historical background
  - Innate and adaptive immunity, Cells and organs of the immune system
  - B cells and antibodies
  - Generation of diversity
  - Antigen presentation and Major Histoincompatibility (MHC) antigens
  - Thymus and T cell selection
  - Autoimmunity
  - Cytotoxic T cells and NK cells
  - Th1 and Th2 cells, regulatory T cells
  - Allergies
  - Hypersensitivities
  - Vaccines, immune-therapeutic interventions

**Literature**

- Electronic access to the documentation will be provided. The link can be found at "Lernmaterialien"
- Kuby, Immunology, 9th edition, Freeman + Co., New York, 2020

**Prerequisites / notice**

- For D-BIOL students Immunology I (WS) and Immunology II (SS) will be examined as one learning entity in a "Sessionsprüfung". All other students write separate exams for Immunology I and Immunology II. All exams (combined exam Immunology I and II, individual exams) are offered in each exam session.
### Public Health Concepts

**W** 3 credits 2V  R. Heusser

**Abstract**
The module "public health concepts" offers an introduction to key principles of public health. Students get acquainted with the concepts and methods of epidemiology. Students also learn to use epidemiological data for prevention and health promotion purposes. Public health concepts and intervention strategies are presented, using examples from infectious and chronic diseases.

**Objective**
- to interpret the results of epidemiological studies
- to critically assess scientific literature
- to know the definition, dimensions and determinants of health
- to plan public health interventions and health promotion projects
- to draw a bridge from evidence to policies and politics

**Content**
Concepts of descriptive and analytical epidemiology, study designs, measures of effect, confounding and bias, screening, surveillance, definition of health and health promotion, health dimensions and health determinants, prevention strategies, public health interventions, public health action cycle, epidemiology and prevention of infectious and chronic diseases (HIV, COVID-19, Obesity, Iodine/PN nutrition).

**Lecture notes**
Handouts are provided to students in the classroom.

### Translational Science for Health and Medicine

**W** 3 credits 2G  J. Goldhahn, C. Wolfrum

**Abstract**
Translational science is a cross disciplinary scientific research that is motivated by the need for practical applications that help people. The course should help to clarify basics of translational science, illustrate successful applications and should enable students to integrate key features into their future projects.

**Objective**
After completing this course, students will be able to understand:
- Principles of translational science (including project planning, ethics application, basics of resource management and interdisciplinary communication)
- How to identify need?
  - Disease concepts and consequences for research
  - Basics about incidence, prevalence etc., and orphan indications
  - How to choose the appropriate research type and methodology
  - Ethical considerations including ethics application
  - Pros and cons of different types of research
  - Coordination of complex approaches incl. timing and resources
  - How to measure success?
  - Outcome variables
  - Improving the translational process
- Challenges of communication?
- How independent is translational science?
- Academic boundary conditions vs. industrial influences

**Content**
Positive and negative examples will be illustrated by distinguished guest speakers.

### Physical Activities and Health

**W** 3 credits 2V  R. Knols, E. de Bruin, further speakers

**Abstract**
This course introduces/explains the complex relationship between physical activity, sedentary behavior and health. It will discuss the evolution of current physical activity recommendations. It will examine the current evidence base that has informed physical activity recommendations and that identified physical activity as a key modifiable lifestyle behavior contributing to disease and mortality.

**Objective**
on completion of this course students will be able to demonstrate:
- knowledge of and critical awareness of the role of physical activity and sedentary behavior in the maintenance of health and the aetiology, prevention and treatment of disease.
- thorough knowledge and critical awareness of current recommendations for physical activity, and current prevalence and trends of physical activity and associated diseases
- awareness of current national and international physical activity policies and how these impact on global challenges

**Content**
Introduction to Physical Activity for Health, including sedentary behavior
- Physical activity epidemiology; concepts principles and approaches
- Physical activity and all cause morbidity and mortality
- Physical activity and chronic disease; Coronary heart disease, diabetes, bone health, cancer and obesity
- Physical activity and brain health
- Physical activity and sedentary behavior recommendations
- Population prevalence of physical activity and sedentary behavior
- Physical activity policies
- Physical activity assessment
Core texts for this course are:

Selective journal articles from relevant journals such as Journal of Physical Activity and Health and Journal of Aging and Physical Activity

Prerequisites / notice
From the BSc-course the following book is recommended: ‘Essentials of strength training and conditioning’ T. Baechle, R. Earle (3rd Edition)

**Master's Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>766-6500-00L</td>
<td>MAS Master's Thesis</td>
<td>O</td>
<td>20</td>
<td>43D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

**Abstract**
The study program is completed with the Master thesis, an independent scientific work. Topics are selected within the domains of the MAS program. The work is supervised by a lecturer of the MAS program.

**Objective**
The Master thesis must demonstrate the student's ability to independent, structured and scientific working.

**MAS in Nutrition and Health - Key for Type**

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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<td>Courses outside the curriculum</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

**Key for Hours**

| V | lecture | P | practical/laboratory course |
| G | lecture with exercise | A | independent project |
| U | exercise | D | diploma thesis |
| S | seminar | R | revision course / private study |
| K | colloquium |   |   |

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## MAS in Fire Safety Engineering

Four-semester, part-time MAS programme, starting in autumn semester (even years).

Next start: Autumn Semester 2022

### Module

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>121-0100-00L</td>
<td>Module 1: Fire Science</td>
<td>O</td>
<td>10 credits</td>
<td>9G</td>
<td>A. Frangi, P. Jenny, M. Klippel, B. Merci, A. Schälin, M. Siemon, B. Zoller</td>
</tr>
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<td></td>
<td>Only for MAS ETH in Fire Safety Engineering.</td>
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<tr>
<td>121-0110-00L</td>
<td>Module 2: Fire Safety Design</td>
<td>O</td>
<td>10 credits</td>
<td>9G</td>
<td>A. Frangi</td>
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<td>Does not take place this semester.</td>
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<td>Only for MAS ETH in Fire Safety Engineering.</td>
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<tr>
<td>121-0140-00L</td>
<td>Module 5: Fire Protection Systems</td>
<td>O</td>
<td>6 credits</td>
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</table>

### MAS in Fire Safety Engineering - Key for Type

- **O**: Compulsory
- **W**: Eligible for credits
- **W+**: Eligible for credits and recommended
- **E-**: Recommended, not eligible for credits
- **Z**: Courses outside the curriculum
- **Dr**: Suitable for doctorate

### Key for Hours

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium
- **P**: practical/laboratory course
- **A**: independent project
- **D**: diploma thesis
- **R**: revision course / private study

ECTS: European Credit Transfer and Accumulation System

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### Module

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>067-0101-00L</td>
<td>Involved Parties</td>
<td>O</td>
<td>10</td>
<td>21G</td>
<td>S. Menz</td>
</tr>
</tbody>
</table>

**Abstract**

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Objective**

The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.
- Expertise and personal skills
- Organisational forms and SWOT analysis
- Role, contracting and authority to issue directives
- Responsibility
- Leadership

**Content**

Our advanced studies' lectures are given in German. Please find an English written abstract and/or keywords in the field 'objective'.

**Lecture notes**

Please find the teaching material, the further readings and information on our server.

**Literature**

www.map.arch.ethz.ch/en

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td></td>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td></td>
<td>Analytical Competencies</td>
<td>Decision-making</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>Critical Thinking</td>
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<td></td>
<td>Problem-solving</td>
<td>Project Management</td>
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<td>Integrity and Work Ethics</td>
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<td>Sensitivity to Diversity</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Negotiation</td>
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<td>Self-direction and Self-management</td>
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</tbody>
</table>

**067-0103-00L**

**Interests**

Only for MAS in Building Process Leadership.

**Abstract**

In our third semester, we reconsider and re-evaluate our identity as a leading consultant. For this we see how the concept of leadership works on and shapes our skills. In line with our acquired knowledge we now pay attention to all involved interests: the perception of demand. Furthermore, it is a necessity to understand the tasks and duties of every role which you can take on.

**Objective**

The students are able to understand the following terminologies, processes and competences. They are able to put them into practice.
- Interests and positions, perception of demands
- Concept of leadership
- Construction industry and real estate market

**Content**

In our third semester, we reconsider and re-evaluate our identity as a leading consultant. For this we see how the concept of leadership works on and shapes our skills. In line with our acquired knowledge we now pay attention to all involved interests: the perception of demand. Furthermore, it is a necessity to understand the tasks and duties of every role which you can take on.

**Literature**

www.map.arch.ethz.ch/en

### MAS in Building Process Leadership - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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### Key for Hours

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<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>independent project</td>
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<tr>
<td>R</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in History and Theory of Architecture (GTA)

The MAS-program in "History and Theory of Architecture" is a two-year half-time course and contains 60 CP. The course starts in the autumn semester.

Attendance of classes supplemented by independent research; practical training periods and excursions; lectures/seminars on one to two days per week, in total 600 ca. contact hours, in addition private study ca. 600 hours (for each in-class day one day of work preparation), two individually tutored seminar papers on chosen subjects (200 hours) and credited Master's thesis (600 hours).

1. Semester

Lectures, Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>056-0001-01L</td>
<td>Architecture and the City I</td>
<td>O</td>
<td>4</td>
<td>4S</td>
<td>S. Schindler Kilian, A. J. Bideau</td>
</tr>
<tr>
<td></td>
<td>Only for MAS in History and Theory of Architecture.</td>
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<td></td>
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</tr>
<tr>
<td>Abstract</td>
<td>The seminar asks: What, exactly, constitutes a &quot;historical moment&quot;? How do so-called forks in the road, paradigm shifts, or turns manifest? We will explore this question with a particular focus on the interplay of architecture, city, and capital by closely looking at a series of historical constellations in the 19th and 20th centuries.</td>
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<tr>
<td>Objective</td>
<td>Through the interpretation of primary and secondary sources from the history of architecture and economics, and the juxtaposition with built works, students learn to understand the intersections between architecture, economics and politics and to articulate those relationships with precision and nuance. They learn to lead discussions and summarize key findings in written form.</td>
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<tr>
<td>Content</td>
<td>In order to identify the continuities and discontinuities between economics and architecture, the seminar is structured around turning points in economic history and related societal shifts. In this way, we will test new ways of conceptualising the relationships between architecture, money and the city in their local and global entanglements.</td>
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<tr>
<td>Literature</td>
<td>Will be posted on the MAS platform.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>None.</td>
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Workshop

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>056-0005-01L</td>
<td>Methods of Academic Writing I</td>
<td>O</td>
<td>1</td>
<td>3U</td>
<td>M.-A. Lerjen</td>
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<td></td>
<td>Only for MAS in History and Theory of Architecture.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Through hands-on teaching, the methods workshops introduce students to the various approaches to academic writing in the humanities and convey the methodological foundations of architectural history. Lecturers and students discuss and work on research papers and master's theses as well as the group's research project.</td>
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<tr>
<td>Objective</td>
<td>Students learn to identify and apply different methods of academic writing in architectural history. They acquire the ability to recognize and independently solve problems related to research and writing.</td>
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</table>

Essays

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<tr>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>056-0201-01L</td>
<td>Scientific Home Work (1)</td>
<td>O</td>
<td>4</td>
<td>3U</td>
<td>S. Schindler Kilian, A. J. Bideau</td>
</tr>
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<td></td>
<td>Only for MAS in History and Theory of Architecture.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Students write a seminar paper on a subject of their choice in consultation with a lecturer, developing the skills to pursue independent academic work.</td>
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<tr>
<td>Objective</td>
<td>Students write an academic paper of approx. 3.000 words/20.000 characters.</td>
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3. Semester

Lectures, Seminars

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>056-0003-01L</td>
<td>Architecture and the City III</td>
<td>O</td>
<td>4</td>
<td>4S</td>
<td>S. Schindler Kilian, A. J. Bideau</td>
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<td></td>
<td>Only for MAS in History and Theory of Architecture.</td>
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<tr>
<td>Abstract</td>
<td>The seminar asks: What, exactly, constitutes a &quot;historical moment&quot;? How do so-called forks in the road, paradigm shifts, or turns manifest? We will explore this question with a particular focus on the interplay of architecture, city, and capital by closely looking at a series of historical constellations in the 19th and 20th centuries.</td>
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<td>Objective</td>
<td>Through the interpretation of primary and secondary sources from the history of architecture and economics, and the juxtaposition with built works, students learn to understand the intersections between architecture, economics and politics and to articulate those relationships with precision and nuance. They learn to lead discussions and summarize key findings in written form.</td>
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<tr>
<td>Content</td>
<td>In order to identify the continuities and discontinuities between economics and architecture, the seminar is structured around turning points in economic history and related societal shifts. In this way, we will test new ways of conceptualising the relationships between architecture, money and the city in their local and global entanglements.</td>
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<tr>
<td>Literature</td>
<td>Will be posted on the MAS platform.</td>
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<tr>
<td>Prerequisites / notice</td>
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<tr>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>056-0009-01L</td>
<td>Architecture and the City V</td>
<td>W</td>
<td>4</td>
<td>9S</td>
<td>S. Schindler Kilian</td>
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<tr>
<td></td>
<td><em>Enrollment only on agreement with the lecturer.</em></td>
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<tr>
<td>Abstract</td>
<td>&quot;Architecture and the City V&quot; serves as the container to register in the transcript the two electives at 2 credit points each which are required from MAS gta students for their degree. Students should register both for this course and for the electives.</td>
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<tr>
<td>Objective</td>
<td>The goal of requiring two electives is to expose MAS gta students to the range of content and methods being taught at gta/DARCH.</td>
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Workshop

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<thead>
<tr>
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<th>Lecturers</th>
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<tr>
<td>056-0007-01L</td>
<td>Research Methods in the History and Theory of Architecture I</td>
<td>O</td>
<td>1</td>
<td>3U</td>
<td>C. Rachele, S. Schindler Kilian</td>
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<td></td>
<td>Only for MAS in History and Theory of Architecture.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Introduction to methodological approaches in the history and theory of architecture; presentation and discussion of individual projects.</td>
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</tbody>
</table>
Objective
The course in the first year of the doctoral program in the history and theory of architecture has a twofold objective: First, method sessions on central approaches in the history and theory of architecture provide a methodological basis for the doctorate at the Institute gta. Secondly, in toolkit and review sessions, the doctoral students get support for their individual research projects and guidance for the production of the Research Plan they have to present at the end of the first year.

Content
The seminar course prepares the doctoral students for their Research Plan submission at the end of their first year. The weekly seminar will frame group discussions on a variety of topics, group presentations, and preparatory exercises. Students are encouraged to consider the course readings not only in terms of their content, but also as illustrations of formatting, structuring and argumentation methods, that can serve as research models.

There are four types of seminar classes. Toolkit classes focus on the individual components of the Research Plan: abstract, hypothesis, literature survey, research structure etc. Method classes cover research strategies and disciplinary traditions relevant for doctoral studies in the history and theory of architecture. Theory seminars focus on specific intellectual traditions and their comparison. The in-seminar Review sessions, leading up to the formal end-of-semester Doctoral Reviews with external guests, comprise work-in-progress presentations and peer-review appraisals.

The course schedule will be available at the beginning of HS 2021 on the course website: https://doctoral-program.gta.arch.ethz.ch/courses/research-methods-in-the-history-and-theory-of-architecture

Lecture notes
Scans of selected texts for discussion and exercises will be provided at the beginning of HS 2021 on the course website: https://doctoral-program.gta.arch.ethz.ch/courses/research-methods-in-the-history-and-theory-of-architecture

Literature
The following titles offer background and detailed information regarding research methodologies for a variety of disciplines.


Master's Thesis
Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---

Abstract
This one-semester module is dedicated to identifying the topic for the Master's thesis and developing the research plan. The Master's thesis itself is written in the following spring semester.

Objective
The aim is to develop a relevant hypothesis and research question for the Master's thesis that is based on an analysis of the current state of the field. Additionally, the research plan includes preparing an annotated bibliography, elaborating the methodological approach and a timeline of deliverables.

Content
The topic of the MAS master thesis is chosen by the students and further refined through individual consultation with the docents. At the end of the semester, the students present their research plan to external guest critics. The research plan comprises about 25,000 characters.

Literature
See internal MAS platform

MAS in History and Theory of Architecture (GTA) - Key for Type

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td></td>
</tr>
</tbody>
</table>

Key for Hours

- V lecture
- G lecture with exercise
- U exercise
- S seminar
- K colloquium

- P practical/laboratory course
- A independent project
- D diploma thesis
- R revision course / private study

- ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Housing

1 year full time course in English, starting every autumn semester.
Further information on www.wohnforum.arch.ethz.ch

Lectures, workshops, individual and group tutorials and excursions organized in the framework of the four modules: Cultural, socio-economic, demographic and political aspects of housing and human settlements (M1); Adequate housing and neighbourhood development strategies (M2); Housing for migrants, refugees, and people displaced by disasters (M3); Housing research and evaluation methods (M4).

Introduction to the MAS Housing: Room HIT H 13 (Date and Time will follow in due time).
Presentation of MAS Thesis Proposals: Room HIT H 13 (Date and time will follow in due time).

<table>
<thead>
<tr>
<th>Core Courses</th>
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<tbody>
<tr>
<td><strong>Number</strong></td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td>057-0103-10L</td>
</tr>
<tr>
<td>Abstract</td>
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<tr>
<td>Objective</td>
</tr>
<tr>
<td>Content</td>
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<td>Lecture notes</td>
</tr>
<tr>
<td>057-0104-10L</td>
</tr>
<tr>
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<td>057-0101-10L</td>
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<tr>
<td>Lecture notes</td>
</tr>
<tr>
<td>Prerequisites / notice</td>
</tr>
<tr>
<td>057-0102-10L</td>
</tr>
<tr>
<td>Abstract</td>
</tr>
<tr>
<td>Objective</td>
</tr>
<tr>
<td>Content</td>
</tr>
<tr>
<td>Lecture notes</td>
</tr>
</tbody>
</table>
Elective Courses

At least 3 elective courses for a total of 6 ECTS have to be followed by the MAS students. These can be selected from the courses offered by the Department of Architecture or from other ETH departments.

**MAS in Housing - Key for Type**

<table>
<thead>
<tr>
<th>Code</th>
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</tr>
</thead>
<tbody>
<tr>
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</table>

**Key for Hours**

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<td>G</td>
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<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Management, Technology, and Economics
MAS MTEC Introductory Event for 1st Semester Students.
Monday, 19.09.2022, 16:00 - 17:15 h, HG E 1.2

1. Semester

Core Courses

General Management and Human Resource Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0341-00L</td>
<td>Introduction to Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>Z. Zagorac-Uremovic, D. Baschung, J. O'Neil</td>
</tr>
</tbody>
</table>

Abstract
By the end of this course, students will understand management as a set of skills, processes, tools and methods that enable organizations to achieve their goals and to coordinate routine operations in order to meet evolving customers' and societal needs. The students will achieve these goals by being able to:
- Analyze organizations as open systems, and describe their critical elements,
- Apply conceptual tools and methods that help to analyze or approach the critical elements,
- Compare different notions of organizational performance, and explain why they matter,
- Discuss the relationships that connect the critical elements of an organization on the basis of real cases,
- Explain how change, internally or externally initiated, impact such relationships

Objective
This course is an introduction to the critical management skills involved in planning, organizing, leading and controlling an organization. This course follows a 'systemic' view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations: Input (i.e., from external environment), strategy, people, work, formal and informal structure of the organization, and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements together by means of real-life cases, whereby the focus will be on the critical reflection of particular cases of fits and misfits between those elements and on the application of a selection of tools and methods.

Content
This course is an introduction to critical management skills involved in planning, organizing, leading and controlling an organization. This course follows a 'systemic' view of organizations and adopts the congruence model as a framework to analyze the critical, interconnected elements of organizations: Input (i.e., from external environment), strategy, people, work, formal and informal structure of the organization, and its outputs. In this course we will introduce these critical elements and learn how managers can analyze and approach these elements by means of different conceptual tools and methods in order to achieve performance. We will furthermore discuss the relationships that connect the critical elements together by means of real-life cases, whereby the focus will be on the critical reflection of particular cases of fits and misfits between those elements and on the application of a selection of tools and methods.

Lecture notes
The content of the course will rely on different readings, cases and selected chapters of following book:

Selected readings from the book and additional learning materials will be available on the course Moodle:
https://moodle-app2.let.ethz.ch/course/edit.php?id=17562

Literature
The content of the course will rely on different readings and on selected chapters of following book:

Selected readings from the book and additional learning materials will be available on the course Moodle:
https://moodle-app2.let.ethz.ch/course/edit.php?id=17562

Prerequisites / notice
Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on moodle. This preparation is required to participate in the lectures.

The final exam is requested for all types of students (BSc, MSc, MAs, PhD, and Exchange students). It is not possible to retake the exam within the same term or academic year.

We strongly recommend Exchange students to take it into consideration when selecting the courses to attend.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Adaptable and Flexibility</td>
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<td>Analytical Competencies</td>
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<td>Customer Orientation</td>
<td>Creative Thinking</td>
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<tr>
<td>Decision-making</td>
<td>Problem-solving</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Problem-solving</td>
<td></td>
<td>not assessed</td>
<td>not assessed</td>
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</table>

Work Design and Organizational Change

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0301-00L</td>
<td>Work Design and Organizational Change</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>G. Grote</td>
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</tbody>
</table>

Abstract
Good work design is crucial for individual and company effectiveness and a core element to be considered in organizational change. Meaning of work, organization-technology interaction, and uncertainty management are discussed with respect to work design and sustainable organizational change. As course project, students learn and apply a method for analyzing and designing work in business settings.

Objective
- Know effects of work design on competence, motivation, and well-being
- Understand links between design of individual jobs and work processes
- Know basic processes involved in systematic organizational change
- Understand the interaction between organization and technology and its impact on organizational change
- Understand relevance of work design for company performance and strategy
- Know and apply methods for analyzing and designing work
The course is organized in a highly interactive fashion, where discussion in class is as important as the input by the lecturer. Understanding the dynamics in organizations is helped enormously by concrete examples, which will be provided by the lecturer, by talks by guest lecturers, and also the students themselves based on their prior experience from working in various roles (as employees, volunteers, student assistants etc.). Through class discussion we aim to deepen the understanding of the themes covered in the course. The current changes in organizations brought about by Covid-19 will also be an important example which allows to illustrate and discuss many of the key concepts of the course.

Specifically, the course will cover the following topics:
- Work design: From Adam Smith to job crafting
- Effects of work design on performance and well-being
- Approaches to analyzing and designing work
- Modes of organizational change and change methods
- Balancing stability and flexibility in organizations as design criterion
- The organization-technology interaction and its impact on work design and organizational change
- Example Flexible working arrangements (e.g. home office)
- Strategic choices for work design

All through the course, students will be guided to work on their projects also, with about 25% of class time devoted to the projects. In the final session, students will present the main results of their projects and discuss main insights also across projects.

A list of required readings will be provided at the beginning of the course.

### Strategy, Markets and Technology

#### Content
The class will center on the importance of marketing as an activity that creates long-term value for the benefit of organizations and their customers. It will teach concepts, frameworks and methods for marketing decision making.

The structure of the course will roughly follow the different steps of the value chain, i.e., the set of activities necessary for offering valuable products to customers. First, it will introduce students to psychological theories that help explain behavior, e.g., purchase behavior. It will also familiarize students with different methods from marketing research, which can be used to identify the needs of customers. Next, the course will look at the role of the marketing mix in satisfying customer needs. For example, the class will cover new product development and pricing. A focus will be on managing profitable, long-term relationships with customers. To this end, students will gain in-depth knowledge on the use of targeted promotions and marketing data to (1) attract, (2) convert and engage and (3) retain customers.

The course is designed to be “hands-on”, with opportunities to apply skills on business cases involving real-world marketing data. It will feature guest lectures from industry experts. The class might be taught in an in-person, remote or in a hybrid format. Students might also be taught via pre-recorded videos and assigned reading material for self-study.

#### Literature

#### Prerequisites / notice
The course includes the completion of a course project to be conducted in groups of four students. The project entails applying a particular method for analyzing and designing work processes and is carried out by means of interviews and observations in companies chosen by the students.

### Information and Operations Management

#### Content
This course provides an overview of Digital Transformation within organizations, the opportunities that come with it, but also the issues managers face transforming their organizations into the digital age. Increasingly, information technology (IT) is not only being used as a tool to improve processes but to also create and capture new customer value and to gain and maintain competitive advantage.

Specifically, this course will cover the following topics:
- Data: 01.11.2022 12:41  
  
  Autumn Semester 2022  
  Page 1492 of 2416
Objective

This course introduces the students the relevant subjects that form the digital transformation agenda of organizations' top-level management. After completing the 4 core learning blocks below, students will be able understand, analyze and critically question organization’s digital transformation processes while also learning the frameworks and tools used by organizations to digitally transform.

1. Digital transformation strategies
2. Organizing the digital transformation
3. Digital transformation and technology
4. Digital transformation within industries

Content

Throughout the course, students will learn from and discuss with guest lecturers their experiences of digital transformation.

Digital Transformation has become a top management theme in almost all forms of organizations and departments within organizations across all industries. It is part of the strategic agenda of management and supervisory boards with dedicated roles to drive forward its design and implementation.

The lecture introduces many of the relevant subjects that together form the digital transformation agenda of organizations’ top-level management. It establishes the main themes, tools, and theoretical concepts. The lecture consists of 4 learning blocks, each with a focus on an area of Digital Transformation, and will feature guest lecturers from industry. The lecture is structured as follows:

Block 1: Strategy
- Digital Business Model Patterns
- Platform Companies
- Subscription Models
- Lessons from Theory Toolbox

Block 2: Organizational
- Towards an Agile Organization

Block 3: Technology
- “Future-proof” Infrastructure

Block 4: Industry
- Digital Transformation in the Health Care Industry
- Digital Transformation in the Automotive Industry

The course is divided into an onsite classroom part and an online self-learning part. All teaching materials will be available through the course page on Moodle.

Literature

All relevant literature is provided via the Moodle platform.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
</tbody>
</table>

363-0445-00L Production and Operations Management W+ 3 credits 2G T. Netland, H. Franke

Abstract

This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

Objective

This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Content

The course covers the most fundamental strategic and tactical concepts in production and operations management (POM). Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:

2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Literature

Suggested literature is provided in the syllabus.
## Subject-specific Competencies

### Concepts and Theories
- assessed

### Techniques and Technologies
- assessed

## Method-specific Competencies

### Analytical Competencies
- assessed

### Decision-making
- assessed

### Media and Digital Technologies
- not assessed

### Problem-solving
- assessed

### Project Management
- not assessed

## Social Competencies

### Communication
- not assessed

### Cooperation and Teamwork
- assessed

### Customer Orientation
- not assessed

### Leadership and Responsibility
- not assessed

### Self-presentation and Social Influence
- not assessed

### Sensitivity to Diversity
- not assessed

### Negotiation
- not assessed

## Personal Competencies

### Adaptability and Flexibility
- not assessed

### Creative Thinking
- assessed

### Critical Thinking
- assessed

### Integrity and Work Ethics
- not assessed

### Self-awareness and Self-reflection
- not assessed

### Self-direction and Self-management
- not assessed

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### Quantitative and Qualitative Methods for Solving Complex Problems

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</tr>
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<tbody>
<tr>
<td>363-0541-00L</td>
<td>Systems Dynamics and Complexity</td>
<td>W+</td>
<td>3 credits</td>
<td>3G</td>
<td>F. Schweitzer</td>
</tr>
</tbody>
</table>

**Abstract**
Finding solutions: what is complexity, problem solving cycle.

**Objective**
- Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption
- A successful participant of the course is able to:
  - understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
  - apply the problem solving cycle as a systematic approach to identify problems and their solutions
  - calculate project schedules according to the critical path method
  - setup and run systems dynamics models by means of the Vensim software
  - identify feedback cycles and reasons for unintended systems behavior
  - analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

**Content**
Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.

The course is structured along three main tasks:
1. Finding solutions
2. Implementing solutions
3. Controlling solutions

**Lecture notes**
The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture

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### Micro and Macroeconomics

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>J.-E. Sturm</td>
</tr>
</tbody>
</table>

**Abstract**
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective**
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1494 of 2416
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

**Content**

This course deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

**Lecture notes**

The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

**Literature**


This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.

**Literature**


Complementary:

GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with necessary knowledge for decision making using accounting information.

The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

Presentation slides will be made available on moodle prior to lectures.

In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share his insights on corporate sustainability with you.

By attending this course, students will be able to:
- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

The first part of the course is devoted to financial accounting. It teaches the principles of double-entry accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

This course is a prerequisite for the course Financial Management.

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### Financial Management

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>363-0711-00L</td>
<td>Accounting for Managers</td>
<td>W+</td>
<td>3 credits</td>
<td>2V</td>
<td>H. Chen</td>
</tr>
</tbody>
</table>

#### Abstract

The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

#### Objective

By attending this course, students will be able to:
- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

#### Content

The first part of the course is devoted to financial accounting. It teaches the principles of double-entry accounting and deals with the recording of commercial transactions on accounts. It describes the work to be carried out at the closing in order to prepare the financial reports according to the generally accepted accounting principles. This type of accounting information is primarily intended for investors and shareholders.

The second part of the course describes the principles of management accounting and explains the different costing methods. It aims to determine the manufacturing cost of production of the different products and services using full and variable costing methods. The accounting information focuses on the internal needs of managers for the purpose of budget preparation and profitability analysis.

This course is a prerequisite for the course Financial Management.

### 3. Semester

#### Core Courses

#### Strategy, Markets and Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0387-00L</td>
<td>Corporate Sustainability</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Hoffmann, J. Meuer, A. Nunez-Jimenez</td>
</tr>
</tbody>
</table>

#### Abstract

The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

#### Objective

Students
- assess the limits and the potential of corporate sustainability for sustainable development
- develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method.
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams with different output formats (tv-style debate, consultancy pitch, technology model walk-through, campaign video)

#### Content

In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share their insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

Lecture notes
http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Presentation slides will be made available on moodle prior to lectures.

TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

### 363-0392-00L

#### Strategic Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0392-00L</td>
<td>Strategic Management</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>A.-K. Weiser</td>
</tr>
</tbody>
</table>

#### Abstract

This courses conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at improving and establishing position of firms within an industry.
The lecture "Strategic Management" is designed to teach relevant competences in strategic planning and -implementation, for both professional work-life and further scientific development. The course provides an overview of the basics of strategy and the most prevalent concepts and methods in strategic management. The course is given as a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the case companies. In two sessions, the students will also be addressing real-time strategic issues of firms that are represented by executives.

**Objective**

The course aims to:

1. Students are able to describe and evaluate fundamental logistics and supply chain concepts
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings
4. Students are familiar with current developments and trends in supply chain practices
5. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
6. Students are familiar with the foundations of the course.

**Content**

Strategic Management offers a combination of lectures about concepts/methods, and case studies where the students solve strategic issues of the involved companies. This aims at addressing students' profound theoretical understanding of important and current topics and also offers an opportunity to present these concepts in front of an audience. This course conveys concepts and methods in strategic management, with a focus on competitive strategy. Competitive strategy aims at analyzing and establishing positions of firms within an industry, securing firm performance. Thus, the course focuses on a number of important topics, such as the evolution of industry, industry structure, the analysis of a firm's resources- and knowledge, and innovation.

In addition, student groups will hold presentations on the four main topics of this class, to further develop concepts and enhance understanding. The presentations will cover Industry Dynamics I, Industry Dynamics II, Resource-Based View of the Firm, Knowledge Based View of the Firm. For all presentations, selected Harvard Business Cases will be used as a common ground for students to start from.

Students are also expected to read and understand the required readings (approx. 15 items) that cover the most important papers and articles from the past 30 years in management and strategy research.

Prerequisites / notice

Number of participants limited to 80. Registration through myStudies (first come, first served). We do not use the mystudies-Waiting List, but a separate internal system. A lot of people deregister at the start of the semester so stay in the waiting list at any point!

For further questions and if you are unable to sign up through myStudies, please contact the course assistant: http://www.smi.ethz.ch/education/strategy/strategic-management.html

For participants of the MAS-MTEC program we offer a complementary course Practicing Strategy in which students will apply the concepts of Strategic Management to their real-life contexts and organizations. Please register simultaneously for both courses if you want to take part in this course.

For more information please see: http://www.smi.ethz.ch/education/practicing-strategy.html

### Information and Operations Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0453-00L</td>
<td>Strategic Supply Chain Management</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Wagner</td>
</tr>
</tbody>
</table>

**Abstract**

The course offers an introduction to the theory and practice of supply chain management. Students will learn how to develop supply chain strategies and supply chain networks based on firms' competitive strategies and marketing priorities.

**Objective**

1. Students can explain the importance of supply chain management for a firm's strategy and success
2. Students are able to apply the tools and methods used to optimize a supply chain structure
3. Students can differentiate supply chain network designs and their applicability in specific company and sector settings
4. Students are able to explain elements of a supply chain structure and their importance for supply chain strategy
5. Students are familiar with current developments and trends in supply chain practices

**Content**

Modern supply chains are not only essential to ensure functioning logistics but also help firms develop and maintain competitive advantage in globalized (supply) markets with numerous partners and competitors. While taking into account future opportunities and risks, effective supply chains ought to be aligned with and support the achievement of the firm's corporate, business, and product strategies. This course will familiarize students with modern supply chain management theory and practice to develop and manage supply chains. Starting with the corporate strategy, firms align their supply chain strategy. They have to manage trade-offs, such as efficiency and responsiveness. Understanding a supply chain's role within a firm and the implications of supply chain strategies for firm performance is the foundation of the course.

Building on the foundations, students get familiarized with the development of a supportive supply chain structure. This structure is in its core made up by logistical elements, such as facilities, inventory management and transportation. At the same time, supply chain management is inevitably cross-functional. As such, information and information infrastructure, sourcing decisions and pricing are further drivers to define a supply chain structure. Students will learn important elements in supply chain structure, including for example forecasting methods and network design modeling and optimization. Case study assignments and practical exercises within lectures allow students to gain hands-on experience and enhance their knowledge.

The wide range of topics involved in supply chain management makes the field very open to innovation and further development. In the course of the lecture, students have the chance to learn and discuss both overall trends and practical insights on development. The course furthermore encourages student involvement within lectures, in exchange with peers and with guest speakers. Case study assignments and tools for self-assessment help students to learn actively and continuously throughout the course.

**Lecture notes**

The course material will be made available for download on Moodle:

https://moodle-app2.let.ethz.ch/course/view.php?id=17834

All organizational matters will be handled by the teaching assistant Christian Wagner (cwagner@ethz.ch). Please use the SSCM Class Forum on Moodle as a first point of contact.

**Literature**

The following textbook is recommended:

The following textbook is supplementary:
This course provides an introduction to operations research methods in the fields of management science and economics. Requisite:

S. Tillmanns

2G

S. Bütikofer van Oordt

Operations Research

Type

W+

Transformation: Corporate Development and IT

ECTS

W+

3 credits

2G

T. Gutzwiller

Objective

The goal of the lecture is to understand the main challenges of corporate transformation and to demonstrate the application of a holistic project procedure model for corporate transformation projects with special emphasis on the alignment of business and IT.

Notice

The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.

Content

The globalization of the world leads to an increasingly faster pace in business transformation. Enterprises have to adapt faster and even faster to the environmental changes in a global economy to remain competitive and to make sure they stay in business. In todays information age this does not only mean to adapt business strategy and business processes but also to adapt information systems to the new circumstances. The fast adaptation though large scale corporate transformation projects that change strategy, business processes and information systems is critical to ensure competitiveness for tomorrow. The introduction of new business processes and information systems typically takes years in very complex large scale projects. Many projects fail because of insufficient alignment between decision makers in business and IT. Unclear understanding of the overall project scope, undefined roles and responsibilities, unclear project processes, quality problems and resistance to change are some typical problems found in such projects. The lecture is subdivided into following modules:

- Corporate development introduction and motivation
- Parallelization of corporate development and complexity reduction
- Planning process and project portfolio management in corporate development
- Management of large scale projects integration of strategy, processes and information systems
- Quality management in large scale projects
- Project management in large scale projects
- Change management within projects.

The lecture is accompanied by four case studies that are used to exemplify the contents of the lecture by applying the concepts to real situations in corporate life.

Quantitative and Qualitative Methods for Solving Complex Problems

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0305-00L</td>
<td>Empirical Methods in Management</td>
<td>W+</td>
<td>3</td>
<td>2G</td>
<td>S. Tillmanns</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this class, students learn how to understand and conduct empirical research. It will enable them to manage a business based on evident-based decision-making. The class includes group assignments, where students will cover small parts of the lecture content in self-created videos.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The general objective of the course is to enable students to understand the basic principles of empirical studies. After successfully passing the class, they will be able to formulate research questions, design empirical studies, and analyze data by using basic statistical approaches.</td>
<td></td>
<td></td>
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<tr>
<td>Content</td>
<td>Data has become an important resource in today’s business environment, which can be used to make better management decisions. However, evidence-based decision-making comes along with challenges and requires a basic understand of statistical approaches. Therefore, this class introduces problems and key concepts of empirical research, which might be qualitative or quantitative in its nature. Concerning qualitative research, students learn how to conduct and evaluate interviews. In the area of quantitative research, they learn how to apply measurement and scaling methods and conduct experiments. In addition, basic statistical analyses like a variance analysis and how to conduct it in a standard statistical software package like SPSS or R are also part of the lecture. The lessons learned from the lecture will empower students to critically assess the quality and outcomes of studies published in the media and scientific journals, which might form a basis of their managerial decision-making. We recommend the lecture also to students without basic statistical skills, who plan to attend more advanced lectures in the field of artificial intelligence such as Marketing Analytics.</td>
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</table>

The lecture will be taught in presence. There will be some non-mandatory online exercises as an additional opportunity to prepare for the exam.

Prerequisites / notice

The course includes out-of-class assignments and projects to give students some hands-on experience in conducting empirical research in management. Projects will focus on one particular aspect of empirical research, like the formulation of a research question or the design of a study. Students will form groups and create a learning video regarding one specific topic. Assignments will be graded and need to be turned-in on time as they will be shown and discussed in class. Students will also have to evaluate the videos of other student groups. Online class participation is encouraged and can greatly improve students’ learning. In this spirit, students are expected to attend class regularly and come to class prepared.

363-1004-00L | Operations Research | W+ | 3 credits | 2G | S. Bütkofer van Oordt |
| Abstract | This course provides an introduction to operations research methods in the fields of management science and economics. Requisite mathematical concepts are introduced with a practical, problem-solving perspective. | | | |
| Objective | - Introduction to building and using quantitative models in a business / industrial environment
- Introduction to basic optimization techniques (Linear Programming and extensions, network flows, integer programming, dynamic and stochastic optimization)
- Understanding the integration of quantitative models into the managerial decision process | | | |
Content
The economic environment of today's companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative models and methods of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analysed and optimised using suitable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:
- Introduction to system modelling and operations research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

Lecture notes
A printed script will be made available.

Literature
Any standard textbook in Operations Research is a useful complement to the course.

Prerequisites / notice
Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.

Micro and Macroeconomics

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0537-00L</td>
<td>Resource and Environmental Economics</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>L. Bretschger</td>
</tr>
</tbody>
</table>

Abstract
Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

Objective
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failures, external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature

Financial Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0723-00L</td>
<td>Corporate Finance</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Kind</td>
</tr>
</tbody>
</table>

Abstract
"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

Objective
Upon successful conclusion of the course, students will …

1) know what corporate finance and corporate governance are about;
2) be able to price a wide array of corporate securities, assets, and projects, e.g., stocks, bonds, and options;
3) master three valuation approaches (discounted cash-flow valuation, relative valuation, and real-options valuation) and know about their applicability, their strengths, and their weaknesses;
4) know how to finance firms at different stages of their lifecycle;
5) be familiar with acronyms, and concepts in the world of finance;
6) know how to relate real-world corporate events (past and current) to concepts learnt in class;
7) have increased their appeal as future manager, employee or entrepreneur by relevant knowledge in the field of finance in general and corporate finance in particular.
"Corporate Finance" is an introductory course that presents those fundamental principles of finance that find direct application in the financial decisions of modern corporations. The course is structured in three parts: (i) Corporate Finance and Corporate Governance, (ii) Investment Decisions/Valuation, (iii) Financial Policy.

In the following, for each of the three parts of the course, key aspects, are listed.

Part I: Corporate Finance and Corporate Governance
- Corporations and their characteristics (e.g., centralized management, limited liability, free transferability of economic claims, legal personality)
- Corporate finance and its goals (e.g., shareholder-value approach vs. stakeholder-value approach)
- Corporate governance problems and possible solutions (e.g., over-investment, under-investment, self-dealing, monetary incentives, board of directors, the market of corporate control, leverage, product-market competition)

Part II: Investment Decisions/Valuation
- Discounting and compounding
- Present value tools (e.g., perpetuities, growing perpetuities, annuities, growing annuities)
- Bond pricing and interest rates (e.g., types of bonds, term structure of interest rates, yield-to-maturity, duration concepts, forward rates, "riding the yield curve")
- Risk and return (e.g., moments of stock returns, modern portfolio theory, capital market line, systematic risk vs. unsystematic risk)
- CAPM in practice (e.g., computation of the risk free interest rate, beta, and the market risk premium; security market line)
- DCF Analysis: Cost of capital and cash flow estimation
- Relative valuation (e.g., earnings multiples, book multiples, sales multiples, fundamental drivers of multiples)
- Real options (e.g., option to abandon, option to delay, option to expand)

Part III: Financial Policy
- Corporate financing (e.g., instruments, internal vs. external financing, equity financing vs. debt financing, crowdfunding, M&M and beyond)
- Payout policy (e.g., dividends, par value reductions, share buybacks, M&M and beyond)

Lecture notes
Slides in English (and any other relevant material) will be available for download on the following website: https://moodle-app2.let.ethz.ch/course/view.php?id=4479

Literature
For the exam, only the material provided will be relevant. However, interested students may refer to the following textbook for an alternative, or a complementary, reading:


<table>
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<tr>
<th>363-0561-00L</th>
<th>Financial Market Risks</th>
<th>W+</th>
<th>3 credits</th>
<th>2G</th>
<th>not available</th>
</tr>
</thead>
</table>

Abstract
I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

Objective
The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

-Development of the concepts and tools to understand these risks and master them.

-Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)

-Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks
Content

1- The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of the perpetual money machine.

2- Risks in financial markets
- What is risk?
- Measuring risks of financial assets
- Introduction to three different concepts of probability
- History of financial markets, diversification, market risks

3- Introduction to financial risks and its management.
- Relationship between risk and return
- Portfolio theory: the concept of diversification and optimal allocation
- How to price assets: the Capital Asset Pricing Model
- How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4- Financial markets: role and efficiency
- What is an efficient market?
- Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
- Deviations from efficiency, puzzles and anomalies in the financial markets
- Financial bubbles, crashes, systemic instabilities

5- An introduction to Options and derivatives
- Calls, Puts and Shares and other derivatives
- Financial alchemy with options (options are building blocks of any possible cash flow)
- Determination of option value; concept of risk hedging

6- Valuation and using options
- A first simple option valuation model
- The Binomial method for valuing options
- The Black-Scholes model and formula
- Practical examples and implementation
- Realized prices deviate from these theories; volatility smile and real option trading
- How to imperfectly hedge with real markets?

7- Real options
- The value of follow-on investment opportunities
- The timing option
- The abandonment option
- Flexible production
- Conceptual aspects and extensions

8- Government bonds and their valuation
- Relationship between bonds and interest rates
- Real and nominal rates of interest
- Term structure and yields to maturity
- Explaining the term structure
- Different models of the term structure

9- Managing international risks
- The foreign exchange market
- Relations between exchange rates and interest rates, inflation, and other economic variables
- Hedging currency risks
- Currency speculation
- Exchange risk and international investment decisions

Lecture notes
Lecture slides will be available on the site of the lecture

Literature
Corporate finance
Brealey / Myers / Allen
Eight edition

+ additional paper reading provided during the lectures

Prerequisites / notice
none

► Skill-Based Training, 1. and 3. Semester

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
365-1099-00L | Design Thinking: A Human-Centred Approach to Problem Solving | W | 1 credit | 1S | A. Cabello Llamas

Abstract
In this course, students get to know Design Thinking, which is an innovation method that can be applied to solve a broad range of problems from product development to social innovation. The students will engage in collaborative team exercise to learn about and directly apply the five typical design thinking steps – empathize, define, ideate, prototype and test – by solving a real-world challenge.

Objective
During the course, students will...

...get to know the design thinking process working on a specific real-world challenge
...learn when to apply design thinking methodology
...learn how to empathize with users, how to formulate a clear problem statement, develop ideas, prototype as well as test them with potential users
During the course, students will...

...get to know the design thinking process as:
- a methodology to develop ideas and concepts – typically in the early phase of the innovation process (the fuzzy-front end)
- a methodology used for product, service and business model innovation
- a methodology used for organizational development: process improvements, redesign of organizational structures, etc.
- learn how to apply the design thinking methodology or parts of it
- learn how to empathize with users: simple interview techniques, observation, etc.
- learn how to formulate a clear problem statement
- learn how to develop ideas: potentially alternative brainstorming techniques
- learn how to prototype ideas with simple means
- learn how to test them with potential users: simple test structures

What the students should learn from the course:
- Students will be able to assess whether Design Thinking is useful methodology to solve challenges they face in their daily business activities
- Students will be able to use elements (i.e. a novel brainstorming technique, a novel feedback method, etc.) in their daily business activities

What the students will NOT learn:
- This 2-day training is by not extensive enough to provide a full-scale design thinking training that enables students to design, organize and run their own design thinking workshops and projects. For this, further courses, trainings and self-guided learning is necessary.

References to institutes, books and other material will be provided.

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>There is no script available.</th>
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</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td></td>
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</tbody>
</table>
| **Objective**| Participants are able to cope with potentially difficult HRM-related situations they may encounter as line managers and team leaders. Based on several core Human Resource Management processes, this seminar teaches practical skills in HRM and leadership in teams. Using a variety of interactive methods and discussions of real-life situations, it provides a highly practice-oriented approach to dealing with potential HRM- and team-related conflicts at work. Topics covered in the seminar include (but are not limited to): questions around hiring new staff, employee motivation (or a lack thereof), measuring performance, fair and effective compensation, pros and cons of monetary incentives, opportunities and limitations of career development in organizations. Furthermore, participants will learn and practically apply techniques that help them to deal with team-related conflicts. Thereby, they gain a better understanding of how and why conflicts in teams may arise and how they can be solved. The success of this seminar depends greatly on active student participation. Sharing real-life examples from participants' various organizational and professional backgrounds provides the material for engaged and insightful discussions in class as well as in small groups. Also, in order to maximize the learning effect of this seminar, participants will be asked to complete a variety of short assignments prior to and between the three modules. The assignments will help them to prepare for the modules and reflect on the various themes in more depth. Based on the assignments, the discussions during the seminar will be much more focused and effective. In the light of this, this seminar offers you the opportunity to acquire competencies in all of the just mentioned subjects and to reflect on your current behaviour as (future) leader. The more familiar we are with ourselves, the more we become aware of our needs, the freer we are to express ourselves and to interact with others. The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader. Be familiar with and feel able to use elements (i.e. a novel brainstorming technique, a novel feedback method, etc.) in your daily business activities. The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader.

| **Literature** | Will be announced and published ahead of each session. |
| **Prerequisites / notice** | Prior participation in Prof. Grote's lecture 'Human Resource Management: Leading Teams' is highly recommended. |

<table>
<thead>
<tr>
<th><strong>365-1019-00L</strong> Human Resource Management: Skills in Practice</th>
<th>W</th>
<th>2 credits</th>
<th>2S</th>
<th>M. Gubler, M. Kolbe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusively for MAS MTEC students (3rd semester). Prior participation in the lecture &quot;Human Resource Management: Leading Teams&quot; (363-0302-00) in spring semester is recommended.</td>
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</tbody>
</table>

| **Abstract** | Based on several core Human Resource Management processes, this seminar teaches practical skills in HRM and leadership in teams. Using a variety of interactive methods and discussions of real-life situations, it provides a highly practice-oriented approach to dealing with potential HRM- and team-related conflicts at work. |

| **Objective** | Participants are able to cope with potentially difficult HRM-related situations they may encounter as line managers and team leaders. Based on several core Human Resource Management processes, this seminar teaches practical skills in HRM and leadership in teams. Using a variety of interactive methods and discussions of real-life situations, it provides a highly practice-oriented approach to dealing with potential HRM- and team-related conflicts at work. Topics covered in the seminar include (but are not limited to): questions around hiring new staff, employee motivation (or a lack thereof), measuring performance, fair and effective compensation, pros and cons of monetary incentives, opportunities and limitations of career development in organizations. Furthermore, participants will learn and practically apply techniques that help them to deal with team-related conflicts. Thereby, they gain a better understanding of how and why conflicts in teams may arise and how they can be solved. The success of this seminar depends greatly on active student participation. Sharing real-life examples from participants' various organizational and professional backgrounds provides the material for engaged and insightful discussions in class as well as in small groups. Also, in order to maximize the learning effect of this seminar, participants will be asked to complete a variety of short assignments prior to and between the three modules. The assignments will help them to prepare for the modules and reflect on the various themes in more depth. Based on the assignments, the discussions during the seminar will be much more focused and effective. In the light of this, this seminar offers you the opportunity to acquire competencies in all of the just mentioned subjects and to reflect on your current behaviour as (future) leader. The more familiar we are with ourselves, the more we become aware of our needs, the freer we are to express ourselves and to interact with others. The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader. Be familiar with and feel able to use elements (i.e. a novel brainstorming technique, a novel feedback method, etc.) in your daily business activities. The seminar will be a mixture of theory inputs, discussions, self-reflecting moments, group work with short presentations as well as some role plays to give you the opportunity not only to get to know the relevant theories and models, but also to apply and test them. This shall enable you to return to your daily work life and be ready for the challenges of being a (future) leader. |

| **Content** | 1 Fundamentals of Communication 2 Communication in Business Life 3 Self-Management 4 Personality and Understanding Human Nature 5 Fundamentals of Leadership 6 Leadership Tools |

<table>
<thead>
<tr>
<th><strong>365-1092-00L</strong> Personal Leadership Skills</th>
<th>W</th>
<th>2 credits</th>
<th>3S</th>
<th>P. Romann</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusively for MAS MTEC students (3rd semester). Please register by 01.06.2022 at the latest via myStudies.</td>
<td></td>
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</table>

| **Abstract** | With the aim of preparing the students to take on managerial responsibility, this 2x3 days-seminar teaches basic and practical management skills. |

| **Objective** | To convey management behaviour based on practical examples, own experiences and team discussions complemented by short theory sessions (subsidized from the donation for promotion and training in enterprise sciences at the ETHZ). |

| **Content** | 1 Fundamentals of Communication 2 Communication in Business Life 3 Self-Management 4 Personality and Understanding Human Nature 5 Fundamentals of Leadership 6 Leadership Tools |

<table>
<thead>
<tr>
<th><strong>365-0347-00L</strong> Negotiation Skills</th>
<th>W</th>
<th>1 credit</th>
<th>1S</th>
<th>M. Gutmann</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusively for MAS MTEC students (3rd semester). Students, who have already successfully completed the course &quot;Negotiation and Advocacy Skills&quot; can't register again.</td>
<td></td>
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</table>

| **Abstract** | Participants are introduced to practical frameworks for negotiations apply them in negotiation simulations, discussions and exercises. |

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1502 of 2416
**Objective**

In this course, participants are introduced to the practical dimensions of how individuals and organizations represent their interests in negotiations. Participants will learn basic frameworks and theories for:

- negotiation context analysis
- preparing to negotiate
- best-practices for effectively negotiating

and apply them to practical contexts through discussions, group exercises, and simulations.

**Content**

This two-day skills course gives students a basic introduction to how individuals and organizations represent their interests and create value in negotiations, which are often defined as exchanges between parties designed to reconcile their differences and produce a settlement. The course comprises a mixture of lectures, discussions, group work, and simulations. Students do not need any experience or knowledge of negotiations, though those that do are invited to share their experience in discussions.

The first day focuses on:

- Planning and preparation for negotiations
- Analyzing and understanding different types of negotiation contexts
- Common frameworks for negotiations
- 2 party negotiation simulation

The second day focuses on:

- Social dimensions (power, influence, persuasion, behavior cues, culture, and gender) of negotiations
- Ethics and ethical dilemmas in negotiations
- 3 party negotiation simulation

The course is structured to give an introductory overview of the topics. Recommended readings for further studies will be provided on moodle. Students will be required to read the instructions for the negotiation simulation before arriving in class. Attendance and participation is required on both course days.

**Literature**

Pre-session reading is composed of:

- instructions/mandate for a negotiation simulations (before each session)

All required and recommended readings will be available on moodle.

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**365-1149-00L Introduction to Personal Branding and Storytelling**

*Exclusively for MAS MTEC students (1st and 3rd semester).*

Please register by 31.08.2022 at the latest via myStudies.

Minimum number of participants: 15 students.

**Abstract**

We all have a "personal brand" - whenever you are interacting others, you are projecting an image of yourself. Are you ready to take charge of your own brand story and proactively guide your image? Would you like to learn how to effectively tell your story in a memorable way? This course will teach you skills you can rely on throughout your career to help you achieve your goals.

Specific take-aways from this course:

- Your current personal brand
- Your desired personal "brand house"
- Storytelling frameworks
- Building of your personal story and practice giving it
- Review of online & offline communication channels with an action plan to activate
- Revision of your LinkedIn profile to reflect your personal brand
- Your Personal Journal to keep and reflect on throughout your career as well as the toolkit you need to refresh your brand house as needed

**Content**

The Personal Branding and Storytelling course will be divided into the following sessions:

Pre-Work: you will be expected to distribute a survey to 5-6 members of your trusted network (e.g. friends, family and work colleagues). The surveys are private and only you will see the information. The survey will be the basis of defining your current personal brand. Additional pre-work will be reading through some articles and completing the first section of your Personal Journal.

**Brand Basics:** gain a common understanding of what a brand really is and why it is important. We will explore the difference between a corporate brand and a personal brand.

**Brand Building:** using the pre-work material, we will look at your current personal brand vs. your desired brand. We will take an in-depth look at all parts of a brand house and help you define your own Unique Selling Points (USPs). We will have exercises and break into small teams as needed.

**Storytelling Basics:** gain a common understanding of the importance of storytelling and different frameworks to approach it.

**Storytelling Practice:** you will spend time developing your personal story. We will have exercises and break into small teams as needed. You will be given the opportunity to tell your story and obtain feedback.

**Communication Channels:** we will review the various online and offline communication channels open to you to build your brand with a strong focus on LinkedIn. You will develop a personal action plan based on the channels most relevant to your industry and profession.

**Fostered competencies**

- Social Competencies
  - Communication
  - Self-presentation and Social Influence
- Personal Competencies
  - Self-awareness and Self-reflection

Attendance at both days of the course, active participation in the exercises and finishing the post-class assignment is mandatory for successful completion of the course. Students will be expected to fully complete the pre-work required, including gathering the Trusted Network Survey data and filling in the first part of the Personal Journal. Literature and readings will be announced beforehand.

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**Electives, 1. and 3. Semester**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>365-1145-00L</td>
<td>Applied Finance and Investment for Managers</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>S. Zaker</td>
</tr>
</tbody>
</table>

Exclusively for MAS MTEC students (3rd semester).

The focus is on how financial and investment theory is applied to real world problems. We compete in the economy, but are also exposed to financial markets. The specific point of view, the language of financial markets are discussed using illustrative case studies. Managers will learn how their company is rated for debt financing; and how its value reflects in the "mirror" of private equity funds.
Objective

- Understanding the mechanisms, language, and drivers of the debt and equities markets
- Apply this understanding to specific corporate situations, such as optimizing the cost of capital (debt and equity) of the firm or projects
- Use these insights to learn to think and act as an investor e.g. for the firm’s own pension fund

Content

Part 1: A Practical Introduction to the Financial Markets

Your Company’s profile in the mirror of financial markets. How would experts analyze your company, its strengths, and weaknesses?

The financial market eco-system. Understanding the cogs and wheels of financial markets, and the existing checks and balances.

Key actors in the financial markets. How central banks, commercial banks, and institutional investor influence market trends.

The business cycles: How and why economies rhyme into and out of growth? The mechanism of boom and bust and recessions.

The debt capital market. How companies can benefit from an understanding of the debt market? The importance of financing choices as a competitive advantage.

The equities capital market. How and why equities are issued? How investors categorize the equities markets?

The derivatives market. The origins and importance of derivative markets. The specific characteristics that make them both very useful and extremely hazardous.

The currency markets. Mechanisms of currency hedging in the International markets. The importance of a sound currency strategy to avoid large losses.

Private equity and venture capital. The actors in private debt and equities. The rise of start-ups within a new financial infrastructure.

Hedge Funds. An important new actor in the financial markets.

Initial public offering. How IPOs are organized and executed. The intricacies of the pricing process. When and how are participants disappointed. IPOs as an indicator for the overall market sentiment.

Part 2: Case Studies

Case study 1. How does your pension fund work?
Case study 2. When Activist Hedge Funds approach a company.
Case study 3. Merger and Acquisitions.
Case Study 4. A Financial Market View of your Firm

365-1143-00L Digital Transformation: Integrating Cloud and Business

Exclusively for MAS MTEC students (3rd semester).

Abstract

Digitalization changes our life and how companies do business. As a consequence, the role of IT and Cybersecurity changes, and these changes create new and unknown disruptive challenges for organizations. Based on practical experience we will look into some of these areas like Cybersecurity, governance, organization etc. always with a risk management focus.

Objective

1. How digital transformation affects businesses (insights across industries), processes and organizations
2. That this is not only a technology but a human change as well
3. How today’s governance and organization need to be adopted to these trends
4. How current Cybersecurity approaches look like integrating the cloud

Content

The role of IT and Cybersecurity changed dramatically over time. The movement to the Cloud and the digital transformation as such is in the process of shaping a new world, cybersecurity (and privacy) being at the core of it. Digital transformation as well as security arrived now at the board level.

This drives a lot of changes in a lot of different areas: The role of internal IT has to be re-defined; governance processes have to be changed, even the impact on finance and budgeting is not to underestimated. This course focuses on these challenges and how they can be approached (and have been approached) in the industry. It will base on practical experience with companies across Europe and in different industries.

Besides touching on the basics of Cybersecurity it gives a broader view on the challenges in today’s architectural and governance frameworks and how you can approach these challenges on the technological as well as on the human side. We will jointly work on how the Cloud influences these developments and what changes are necessary to capture the opportunities while maintaining an acceptable risk level.

We want to approach this in an interactive format, while adding background information over the course of the first day (e.g. an introduction to Cybersecurity). Between the first full day and the day 2 (half-day) you work on a case study to be presented and discussed on day 2. On the final slot we will wrap up and fill the blanks and address the questions which remained open.

365-1083-00L Leading the Technology-Driven Enterprise

Does not take place this semester.
Exclusively for MAS MTEC students (1st and 3rd semester).
An enrolment for the lecture “Introduction to Management” (363-0341-00) is mandatory.

Abstract

The bloc-course is about change leadership. It provides MAS students with coaching and mentoring from two senior change leaders in the attempt to develop critical management skills and bridge the gap between theory and practice.

Objective

The general objective of the course is to enable MAS students with post work experience to think critically about concepts discussed in class during the course on Introduction to Management (i.e., the transformation process by Nadler and Tushman, 1980) and their own professional challenges.
Content

In today’s VUCA world that is Volatile, Uncertain, Complex and Ambiguous, how will you lead disruptive change due to Innovation and Technology evolution instead of being swept away by it? Have you mastered the process of leading change? Do you have a specific plan of action for the most critical problem you are trying to solve right now? If not, this is the course for you. You will learn lessons from relevant, current case studies that will bring out specific learnings in each of the 4 modules of the class – Innovation, Change Management, Leadership and Application.

The first module explores how you can be a practical and effective Innovator as an Intrapreneur Leading an established Technology Driven Enterprise, or as an Entrepreneur. Starting with clear definitions of the ‘problem’ and the ‘customer’, you will work through the steps of clarifying the value proposition of the innovative process or product, testing, pivoting and fast iterations, and moving with confidence to implementation.

With Technology and Innovation being necessary but insufficient starting points, the next two modules will dig deep into successful Change Management and Leadership at all levels to ensure aligned and effective execution. The case studies will highlight both successes, and failures, of prior experiences.

This course is taught ‘by practitioners for practitioners’ with the final module focused on a customized Framework of Application introduced during prior modules. You will bring your priority challenge to the class, and through small group work and individual coaching, you will develop a plan of action. A final ‘elevator speech’ will give immediate feedback with which you can enhance the plan and apply it immediately back in your organization.

Separately, the D-MTEC MAS Mentoring Programme is available, should you desire continuing help to support your planning and execution after the course, or more generalized career development ideas.

Literature

Literature and readings will be announced beforehand.

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365-1166-00L Lean Production

| W | 1 credit | 1V | T. Netland, R. Lorenz |

Abstract

This course (i) introduces the fundamentals of Lean Production and (ii) shows how new Industry 4.0 technologies can support a lean transformation. Through lectures, hands-on serious games, reflection and discussions, students learn (i) how lean production differs from other forms of production and (ii) how lean in synergy with new technologies can increase productivity in a production setting.

Objective

After taking this course, students will be able to:
1. Operationalize and apply the just-in-time principle in manufacturing
2. Design a production system that minimizes quality errors
3. Work in a team to solve problems with selected problem-solving tools
4. Understand the role of behaviours and leadership in lean transformations
5. Select and apply new Industry 4.0 technologies to support the lean transformation

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365-1059-00L Practicing Strategy

| W | 1 credit | 1S | S. Herting |

Abstract

This lecture is a special course for MAS MTEC students which supplements the Strategic Management course. Participants work on real-life strategy problems in a two-day workshop and apply concepts & methods from the Strategic Management course to develop suitable solutions.

Objective

The course has two goals. First, participants learn to decompose complex real life problems into underlying strategic issues. Second, students learn to transfer and use the concepts and methods from the Strategic Management lecture to develop solutions for the identified strategic issues in real-life business contexts.

Content

The course consists of two workshop days. However, most work for participants takes place in the phase between the two workshop days when participants engage in group work to solve a real-life strategic issue.

First workshop day:
Participants revisit core concepts and methods from the Strategic Management lecture. Moreover, participants learn the conceptual steps of defining strategic questions and developing suitable solutions for real-life settings. This conceptual process is then illustrated with an in-depth case study of a strategy consulting project that one of the lecturers conducted. The second part of the workshop day is the starting point for the group work phase. Participants identify a strategic problem that they face at work and team up (each group consists of 4-6 participants) to develop solutions by applying the concepts and methods from the Practicing Strategy class. At the end of the first workshop day, each group has defined one strategic question and developed a rough course of action for developing solutions until the second workshop day.

Between workshop days:
Participants work in small groups to develop solutions for the strategic problem that they identified on the first workshop day. This phase requires participants to select concepts and methods that are suitable to approach the strategic question. Moreover, students collect and analyze data. Subsequently, participants draw upon their analysis to develop solutions to the strategic problem. In this phase, participants can rely on the support and feedback from the teaching team.

Second workshop day:
Participants present their group work followed by an in-depth discussion and feedback session for each group project.

Prerequisites / notice

Successful registration and participation (either parallel enrollment or successful completion in a previous semester) in the course “Strategic Management” is required (see Course Catalogue page for details).

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365-1142-00L Understanding Human Behavior - Research and Business Insights

| W | 1 credit | 1V | S. Andraszewicz |

Abstract

Human capital is the most precious resource of every company, while customers are the backbone of a company’s functioning. This course demonstrates applications of behavioral science theories to improve decision making within the company and to better understand its customers. In this course, psychology meets finance, data science and analytics to address practical business problems.

Objective

The course objective is to provide a crash-course of behavioral economics and decision science with a special focus on aspects particularly important in business and international companies. The aim of the course will be to apply theoretical knowledge obtained during the classes at ETH in practical business cases stemming from ETH industry partners.
Why incredibly intelligent people do incredibly stupid things? What are the most frequent dynamics associated with corporate fraud and 

This block course is divided into three sessions:

1. Theory Part: Students get familiar with the Nobel-Prize winning theories, key concepts, models and findings in decision science and 
behavioral economics. The covered topics include judgment and decision making, heuristics, biases and heuristics, nudges, 
psychometrics, risk appetite elicitation, digital and physiological footprints of decisions, and impact of emotions and environment on 
decisions. The material will be aligned with relevant real-life examples that relate to important societal and business problems. The 
students will be introduced to the behavioral study design, behavioral analytics and research methods that can be applied in a business 
environment accounting for its advantages and limitations.

2. Business Insights Part: In this part students learn how the behavioral aspects enter into business processes, workflows and customer 
relations. An industry partner (Swiss Re) will present a business case related to behavioral science. Studenten challenge these cases in 
groups based on the theoretical part and guidance from lecturers. Students will form groups to solve the business case, using the knowledge 
acquired during the theoretical part of the course and relevant course material.

3. Final Presentation Part: This session will take place at the industry partner’s venue, where the students will present their business case 
solutions.

Attendance during the meetings and solving the business case are mandatory requirements for successful completion of the course. 
Course material includes the lecture slides and scientific papers.
The seminar "Cases in Technology Marketing" introduces students to key concepts and tools in technology marketing and familiarizes them with the challenges that marketing managers face in technology intensive markets by using real life cases. The seminar allows for in-depth discussions of the real-life case solution with the C-level manager and hereby enables students to transfer their teamwork abilities besides the application of theoretical concepts to the applied case questions. The students will have to present their case solutions to the lecturer and a top executive of a leading Swiss company (details see below). Also, they will be enabled to compare their solutions with what has actually been done or is yet to be done.

The three case studies presented in this course cover real managerial issues of the Swiss manufacturer Bühler AG (www.buhlergroup.com). A Bühler top executive will present the cases and discuss the students' presentations and solutions. As such, the course allows for in-depth discussions of the real-life case solution with the C-level manager and hereby enables students to transfer their learnings from theoretical considerations to the applied field. The course will be rounded off with a day-visit to the Bühler facilities in Uzwil, Switzerland, where students will have the chance to further connect with management and discuss the acquired key concepts, tools, and case study insights on site.

In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 20.08.2021 to Theresa Schachner: tschachner@ethz.ch.

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**Content**

- Understanding current challenges of managers in technology intensive markets
- Defining and analyzing comprehensive business problems using the example of a leading Swiss manufacturing company (Bühler AG)
- Developing and evaluating different alternative case solutions
- Making decisions on case solutions, justifying and defending them
- Transferring case solutions into practice by formulating specific instructions for the management
- Creation of novel, innovative ideas that help the company to gain a competitive edge
- Cooperation in teams and coordination of team tasks
- Adequate communication to and eye-level discussions with C-level managers

**Objective**

- 1. Understanding and applying common business tools and frameworks
- 2. Understanding current challenges of managers in technology intensive markets
- 3. Defining and analyzing comprehensive business problems using the example of a leading Swiss manufacturing company (Bühler AG)
- 4. Developing and evaluating different alternative case solutions
- 5. Making decisions on case solutions, justifying and defending them
- 6. Transferring case solutions into practice by formulating specific instructions for the management
- 7. Creation of novel, innovative ideas that help the company to gain a competitive edge
- 8. Cooperation in teams and coordination of team tasks
- 9. Adequate communication to and eye-level discussions with C-level managers

**Prerequisites / notice**

In addition to course enrolment, students have to apply for this course by sending a CV and a short motivation letter until 20.08.2021 to Theresa Schachner: tschachner@ethz.ch.
The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course, we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

The course has four core learning objectives. Students should:

- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amounts of physiological, environmental, and behavioral observations can be collected with consumer-centric devices. To derive clinical meaningful information from this data, it is complex, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantages as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

The course homepage can be found at: http://www.smi.ethz.ch/education/corporate-strategy.html

Prerequisites / notice

Prerequisites / notice

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Analytical Competencies
Problem-solving
Creative Thinking
Critical Thinking
Self-direction and Self-management

Method-specific Competencies
Assessed
Assessed
Assessed
Assessed
Assessed
Assessed

Personal Competencies

- 363-1163-00L Developing Digital Biomarkers

W 3 credits 2V F. Da Conceição Barata

Particularly suitable for students with a technical background who are interested in healthcare.

Abstract

The course gives an introduction to digital biomarkers and provides students with the foundations to develop their own digital biomarkers. More specifically, the course will cover fundamental topics such as designing observational studies, collecting, and exploring data generated by consumer-centric devices, and applying analytical methods to predict health-related outcomes.

Objective

The widespread use of mobile technologies (e.g., wearable sensors, mobile applications, social media, and location-tracking technologies) has the potential to meet the health monitoring needs of the world’s aging population and the ever-growing number of chronic patients. However, this premise is based on the application of Machine Learning algorithms that allow us to use this data in many different ways. In this course, we will analyze systematic ways to collect data, review the most relevant methods and applications in healthcare, discuss the main challenges they present and apply the newly gained knowledge in practical assignments.

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- understand the anatomy of digital biomarkers
- understand the potential and applications of digital biomarkers
- be able to critically reflect and assess existing digital biomarkers
- be able to design and implement a digital biomarker

Content

The course will consist of four topic clusters that will allow the discussion of the most relevant digital biomarker applications in healthcare:

1) Digital Biomarkers: From biological to digital biomarkers. How are they motivated, defined and how can they be leveraged for monitoring? Prognostic vs. diagnostic vs. predictive biomarkers. Passive sensing vs. active sensing. Digital biomarker vs. Digital therapeutics.

2) Consumer-centric device data: Today, vast amounts of physiological, environmental, and behavioral observations can be collected with consumer-centric devices. To derive clinical meaningful information from this data, it is complex, difficult. We will analyze strategies for extracting knowledge from those measurements.

3) Methodology: In the last decade, neural networks (also known as “deep learning”) have helped push the boundaries of the state-of-the-art in a myriad of domains. They have also uncovered a number of different problems. We will discuss advantages and disadvantages as well as alternative methods for their application to digital biomarker data.

4) Applications: Digital biomarkers are still an emerging subfield, but given that longitudinal in digital biomarker data are arguably easy to acquire in large quantities, it is expected that many relevant Machine Learning applications will emerge in the near future. We will review and discuss current applications and challenges.

Literature


Some programming experience in Python is required, and some experience in Machine Learning is highly recommended.
Abstract

Today, we face the challenge of chronic conditions. Personal coaching approaches are neither scalable nor financially sustainable. The question arises, therefore, to which degree Digital Health Interventions (DHIs) are appropriate to address this challenge. In this lecture, students will learn about the need for, as well as the design, implementation, and assessment of DHIs.

Objective

- To understand the importance of digital health interventions for the prevention, management, and treatment of non-communicable diseases and common mental disorders
- To discuss the opportunities and challenges of digital health interventions (e.g., data collection with wearables, smartphone- and chatbot-delivered health interventions)
- To gain hands-on experience in the conceptual design, implementation and evaluation of a wearable- and smartphone-based digital health intervention

Content


Digital health applications use information, sensor and communication technology to understand, prevent, manage, or treat diseases. The design of these applications requires interdisciplinary expertise at the intersection of medicine, psychology, computer science, technology, management, economics, and law. Only a close collaboration between experts from these disciplines and a specific target population can lead to a shared understanding of the problem at hand and, as a result, highly effective digital health applications. For this reason, national and international students studying computer science, business informatics, psychology, management, economics, or law are invited to work collaboratively with medical students.

Digital health applications and companies have the goal of advancing health care services to fight the ongoing increase of non-communicable diseases (NCDs) and common mental disorders (CMDs) in developed countries. To this end, the question arises of how to develop evidence-based digital health interventions (DHI) that allow medical doctors and other caregivers to scale and tailor long-term treatments to individuals in need at sustainable costs. Through input lectures and practical applications, this module has, therefore, the objective to help students to better understand the need, design, implementation, and evaluation of DHIs.

The following topics are covered:
1. DHIs for the prevention, management, and treatment of NCDs and CMDs
2. Strategies for long-term compliance with DHI
3. Conceptual design of a wearable- and smartphone-based DHI
4. Technical implementation of a wearable- and smartphone-based DHI
5. Evaluation of a wearable- and smartphone-based DHI

Literature

All relevant learning material will be made available via the online learning platform. Moreover, the content of this module is drawn from the experience of the lecturers and the following work:

1. Bablum GM, IG Marques, DX Marquez, et al. (2021) Using Fitbit as an mHealth Intervention Tool to Promote Physical Activity: Potential Challenges and Solutions, Journal of Medical Internet Research (JMIR) 9(3):e25289, 10.2196/25289

363-1082-00L Enabling Entrepreneurship: From Science to Startup

Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch

Abstract

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

Objective

Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea.
The students would cover the following topics, as the build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognise its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders’ agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

Lecture notes
Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

Literature
Book
Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

Prerequisites / notice
This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.

Fostered competencies

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Media and Digital Technologies</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Project Management</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
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<tr>
<td>not assessed</td>
<td>Leadership and Responsibility</td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td></td>
<td>assessed</td>
<td>Self-direction and Self-management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>not assessed</td>
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</tbody>
</table>

Limited number of participants.

Students apply for this course via the official website no later than 21.08.2022 (https://www.mtec.ethz.ch/studies/special-programmes/els.html). Once your application is confirmed, registration in myStudies is possible.

Abstract
This seminar provides master and PhD students at MTEC with the challenging opportunity of a real case on strategy, innovation and leadership in close collaboration with the senior management of a leading Swiss healthcare company: F. Hoffmann-La Roche AG.

Objective
The general objective of the course is to enable MTEC students to develop leadership skills by dealing with real-world business problems, thinking critically about the concepts discussed in their study programs and learning how to apply these concepts to provide practical implications. It provides students with coaching and mentoring from senior leaders in the company and professors from D-MTEC to bridge the gap between theory and practice.
This seminar provides ambitious ETH students and doctoral candidates with a rewarding learning opportunity: a real case study of strategy and innovation in close collaboration with the top management of an outstanding company: Georg Fischer.

What you can expect:

You will work in teams on specific high priority assignments that flow from the company. Delving into the assignments you will both contribute to solving strategic issues and have an impact on their implementation at the company.

To gain insight into the company and its culture you will receive briefings from senior management, conduct interviews with experts and run workshops with your case managers. In the final presentations you will pitch your findings to key stakeholders and top management representatives and receive valuable feedback.

Furthermore you will be coached and supported by MTEC professors on the topics of project scoping, problem definition and solving, process improvement, strategy and board presentation.

The course is directed and organised by PD Dr. Zeynep Erden and Dr. Isabel Spicker as part of the MTEC Leadership Development Programme.

What we expect from you:

You are an ambitious ETH student or doctoral candidate who is looking for a rewarding learning opportunity and is eager to go the extra mile. You will work on a real case study of strategy, technology and innovation in close collaboration with the senior management of an outstanding Swiss company. The recommendations that you formulate in collaboration with members of your team as well as with internal and external experts will be discussed at the Partner and Director levels. This demands a deep understanding of the company’s leadership culture.

In this endeavour you are coached and supported by

- Stefano Brusoni, Chair of Technology and Innovation Management
- Georg von Krogh, Chair of Strategic Management and Innovation
- Torbjorn Netland, Chair of Production and Operations Management
- Zeynep Erden, Lecturer, D-MTEC

Literature and readings will be announced in the coaching sessions. Please apply for this course via the official website (https://mtec.ethz.ch/studies/programme-elements/special-programmes/els.html). Apply no later than August 22. The number of participants is limited to 18.

ECTS: 4

Participants receive a certificate.

Participation in both sessions and completion of all assignments is required to receive the credit.

This course requires preparation time and completion of an assignment before the first course day. Please check the Moodle course page for more information.

Students learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop their own research projects.

You will learn how to approach management research from various perspectives, how to evaluate empirical research, and how to develop your own research project. The successful completion of the course will help you to:

- Think critically and make compelling arguments about the strengths and weaknesses of published management research
- Find and review appropriate literature and previous research for your thesis
- Develop and frame interesting and relevant research questions and problem statements
- Design your research and choose an appropriate methodology for analysis (specific research methods and techniques are not discussed in this course)
- Structure your manuscript
- Plan and manage your thesis project

This course combines lectures, group discussions and individual assignments.

Day 1: Course introduction, group analysis exercises and discussions, lectures on main topics.

Between course days 1 and 2: Individual and group work on assignments.

Day 2: Assignment review and discussion, lectures on main topics, conclusion session.

Target audience:

The course is designed with two groups of students in mind: first, students who write their master thesis at the SMI chair and second, students who write their master thesis in the field of management at other MTEC chairs.

For both groups, the focal topics of this course will arise frequently during the journey of writing their thesis, and the majority of topics are relevant for all students. However, we will provide some specific content (grading guidelines, thesis format) which might not be applicable for students tutored at other MTEC chairs.

Course topics:

1. Thesis topic and thesis proposal:
   - Choice of thesis topic, identification of research gap, formulation of research questions, writing of thesis proposal
2. Literature review:
   - Search and evaluation of academic literature, use of reference tools, writing of theoretical background chapter of thesis
3. Empirical research design:
   - Types of empirical research designs, choice of methodology, overview of data collection and analysis methods
4. Research output and report:
   - Writing of introduction, results and conclusion, thesis format and structure
5. Thesis assessment:
   - SMI grading criteria, MTEC guidelines

References:


The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations.

The course covers the economics of risk and insurance, in particular the following topics will be discussed:

- Models of insurance demand, risk sharing, insurance supply.
- Information issues in insurance markets.
- Advanced topics in microeconomics and behavioral economics.
- The macroeconomic role of insurers and insurance regulation.

The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

This course is for all students who write their master thesis at the Department of Management, Technology, and Economics.

The course is required for all M.Sc. students and MAS students who write their master thesis at the Chair of Strategic Management and Innovation.

The course is graded based on the assignments, peer feedback, and participation in group discussions. The first assignment is due before the first course day. Please check the assignments on the Moodle coursepage. If you sign up for the course on short notice before the first course day, please advise the lecturer of your registration by email.

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cybersecurity, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management:
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

- Group projects related to company case studies

There is no script, but slides will be made available before the lectures.

There are texts for each of the course topics made available before the lectures.

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Abstract
This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

Objective
This course intends to enable all students to:

- Acquire and understand the basic jargon necessary to discuss, in a precise and concise manner, innovation processes and their outcomes
- Analyse the relationship between individual and organizational decision processes and their innovative outcomes
- Discuss the relevance and importance of different decision-making criteria, and critically assess their impact on desired innovative outcomes

Content
This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

How do firms organize to take these decisions? What kind of management skills are necessary to take them? What kind of tools and methods are deployed to sustain managerial decision-making in highly volatile environments? These are the central questions on which this course focuses, relying on a combination of lectures, case-based discussion, and guest speakers.

Prerequisites / notice
The course content and methods are designed for students with some background in management and/or economics

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Fostered competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
<td>Personal Competencies</td>
<td>Problem-solving</td>
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</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Critical Thinking</td>
<td>assessed</td>
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</table>

363-0790-00L Technology Entrepreneurship W 2 credits 2V F. Hacklin

Abstract
Technology ventures are significantly changing the global economic picture. Technological skills increasingly need to be complemented by entrepreneurial understanding.

This course offers the fundamentals in theory and practice of entrepreneurship in new technology ventures. Main topics covered are success factors in the creation of new firms, including founding, financing and growing a venture.

Objective
This course provides theory-grounded knowledge and practice-driven skills for founding, financing, and growing new technology ventures. A critical understanding of dos and don'ts is provided through highlighting and discussing real life examples and cases.

Content
12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15’: Introduction
60’: (Guest) lecture
15’: Discussion related to topic (in groups)
10’: Plenary discussion
20’: Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

Lecture notes
Lecture slides and case material

see elective courses MTEC MSc

► Master’s Thesis

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<tr>
<th>Number</th>
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<tr>
<td>365-1170-00L</td>
<td>Epigeeum’s Avoiding Plagiarism</td>
<td>O</td>
<td>0</td>
<td>external organisers</td>
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</table>

Abstract
Epigeeum’s Avoiding Plagiarism Online Course covers the basics on how to avoid intentional as well as unintentional plagiarism and how to correctly use citations and references.
Objective

The course should be considered as the minimum knowledge standard. Especially for students with less expertise in structuring and writing academic texts we recommend to attend specifically designed preparation courses which provide a more comprehensive and in-depth guidance (please see Study Plan and Master Thesis Guidelines).

By the end of this course, you will be able to:

- Define plagiarism and describe different types of plagiarism
- Recognise and describe key terms relating to plagiarism
- Understand the importance of referencing
- Compile accurate citations and references
- Correctly paraphrase and acknowledge others' work
- Make better use of referencing software to manage your citations and references
- Develop strategies to help you avoid plagiarism in your own work.

Content

This course is designed to help you understand what plagiarism is and how to avoid it.

The key features of the course include:

- Interviews with students and tutors sharing their thoughts on plagiarism
- Key terms and different types of plagiarism explained
- Interactive activities to help you learn what plagiarism is
- Interactive activities to help you practise how to correctly cite and reference different sources
- Strategies to help you develop an action plan to avoid plagiarism
- Online resources to help extend your learning, including articles on real-life cases of plagiarism.

Prerequisites / notice

Plagiarism guidelines defined by ETH Zurich are authoritative.

<table>
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<tr>
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<th>Course Title</th>
<th>Credits</th>
<th>Key for Type</th>
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<tbody>
<tr>
<td>365-0899-00L</td>
<td>Master's Thesis in a Company</td>
<td>12</td>
<td>O</td>
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</table>

Abstract

In the Master thesis students prove their ability to independent, structured and scientific working. In the Master’s thesis students prove their ability to do independent, structured and scientific work. The Master’s thesis is written in collaboration with an industrial partner, organisation or institution and is supervised by an MTEC professor and a company supervisor.

Company supervisor:
The Master’s thesis is written in collaboration with an industrial partner, organisation or institution (all of which may be referred to as a company in the following). A company employee acts as external supervisor for the Master’s thesis.

Supervising professor:
In addition to a company supervisor, you need a D-MTEC professor to serve as the main supervisor of your thesis.

Prerequisites / notice

You have to fulfil the following requirements before you can register for a Master’s thesis:

- You must have passed the “365-1170-00L Epigeum’s Avoiding Plagiarism Online Course” which covers anti-plagiarism topics and citation rules in your 1st semester of study. Handling the intellectual property of others is not only an integral part of the Master’s thesis, but also a part of every semester paper you will write at ETH.

- You must have read the “Citation Etiquette” information sheet on plagiarism (https://ethz.ch/content/dam/ethz/special-interest/study-programme-websites/mas-mtec-dam/Education/education-files/Citation%20etiquette%20-%20plagiarism-citationetiquette.pdf)

MAS in Management, Technology, and Economics - Key for Type

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<td>Eligible for credits and recommended</td>
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<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

<table>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
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<td>S</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Medical Physics

Compulsory Courses (for both Specialisations)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>465-0953-00L</td>
<td>Biostatistics</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>B. Sick</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course deals with simple quantitative and graphical as well as more complex methods of biostatistics. Contents: Descriptive statistics, testing hypotheses, confidence intervals, correlation, simple and multiple linear regression, classification and prediction, diagnostic tests, measurement of agreement, causality versus association.</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
| Objective    | - know the commonly used methods in biostatistics  
- perform simple data analysis with R |
| Literature   | Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011 |
| Prerequisites| Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming |
| Lab / notice | Lecture notes and handouts |
| Fostered     | Subject-specific Competencies                  |      |      |       |            |
|              | Concepts and Theories                          |      |      |       | assessed   |
|              | Techniques and Technologies                    |      |      |       | assessed   |
|              | Method-specific Competencies                   |      |      |       |            |
|              | Analytical Competencies                        |      |      |       | assessed   |
|              | Decision-making                                |      |      |       | not assessed|
|              | Media and Digital Technologies                 |      |      |       | not assessed|
|              | Problem-solving                                |      |      |       | assessed   |
|              | Social Competencies                            |      |      |       |            |
|              | Communication                                  |      |      |       | assessed   |
|              | Cooperation and Teamwork                       |      |      |       | assessed   |
|              | Personal Competencies                          |      |      |       |            |
|              | Adaptability and Flexibility                   |      |      |       | not assessed|
|              | Creative Thinking                              |      |      |       | assessed   |
|              | Critical Thinking                              |      |      |       | assessed   |
|              | Integrity and Work Ethics                      |      |      |       | not assessed|
|              | Self-direction and Self-management             |      |      |       | not assessed|

| 227-0385-10L | Biomedical Imaging                             | O    | 6    | 5G   | S. Kozerke, K. P. Prüssmann |
| Abstract     | Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures. |
| Objective    | Upon completion of the course students are able to:  
- Explain the physical and mathematical foundations of diagnostic medical imaging systems  
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function  
- Design a basic diagnostic imaging system including data acquisition and data reconstruction  
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications  
- Introduction (intro, overview, history)  
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)  
- X-rays (production, tissue interaction, contrast, modular transfer function)  
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)  
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)  
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PECT)  
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)  
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)  
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)  
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)  
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)  
- Ultrasound (spatial and temporal resolution, phased arrays)  
- Ultrasound (Doppler shift, implementations, applications)  
- Summary, example exam questions |
| Lecture notes| Lecture notes and handouts |
| Literature   | Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011 |
| Prerequisites| Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming |
| Fostered     | Subject-specific Competencies                  |      |      |       |            |
|              | Concepts and Theories                          |      |      |       | assessed   |
|              | Techniques and Technologies                    |      |      |       | assessed   |
|              | Method-specific Competencies                   |      |      |       |            |
|              | Analytical Competencies                        |      |      |       | assessed   |
|              | Decision-making                                |      |      |       | not assessed|
|              | Media and Digital Technologies                 |      |      |       | not assessed|
|              | Problem-solving                                |      |      |       | assessed   |
|              | Social Competencies                            |      |      |       |            |
|              | Communication                                  |      |      |       | assessed   |
|              | Cooperation and Teamwork                       |      |      |       | assessed   |
|              | Personal Competencies                          |      |      |       |            |
|              | Adaptability and Flexibility                   |      |      |       | not assessed|
|              | Creative Thinking                              |      |      |       | assessed   |
|              | Critical Thinking                              |      |      |       | assessed   |
|              | Integrity and Work Ethics                      |      |      |       | not assessed|
|              | Self-direction and Self-management             |      |      |       | not assessed|

| 465-0966-00L | Physics in Radiodiagnostic and Nuclear Medicine| O    | 2    | 3G   | F. Bochud |
| Abstract     | The course is dedicated to introduce MAS students from Medical Physics to the field of radiodiagnostic and nuclear medicine. Dedicated practicals will illustrate the theory with an emphasis on the relationship between dose and image quality as well as the security problems related to the work with radiations. |
| Objective    | This 1-week theory and practical class offers the possibility to enjoy a variety of research and clinical areas in diagnostic and nuclear medicine. It gives insight into practical concepts and techniques that are discussed thoroughly as the class is performed within actual laboratories with real radiation sources. |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1515 of 2416
Specialisation in Radiation Therapy

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>O</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.

Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiotherapy, radiology and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Lecture notes
A script will be provided.

Prerequisites
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

Radiobiology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0943-00L</td>
<td>Radiobiology</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>M. Pruschy</td>
</tr>
</tbody>
</table>

Abstract
The purpose of this course is to impart basic knowledge in radiobiology in order to handle ionizing radiation and to provide a basis for predicting the radiation risk.

Objective
By the end of this course the participants will be able to:

a) understand the 5 Rs of radiation oncology in the context of the hallmarks of cancer
b) follow rational strategies for combined treatment modalities of ionizing radiation with targeted agents
c) understand differences in the radiation response of normal tissue versus tumor tissue
d) understand different treatment responses of the tumor and the normal tissue to differential clinical-related parameters of radiotherapy (dose rate, LET etc.).

Content
Einführung in die Strahlenbiologie ionisierender Strahlen: Allgemeine Grundlagen und Begriffsbestimmungen; Mechanismen der biologischen Strahlenwirkung; Strahlenwirkung auf Zellen, Gewebe und Organe; Modifikation der biologischen Strahlenwirkung; Strahlenzügigkeit; Chromosomenschäden, DNA-Damage, Reparaturprozesse; Molekulare Strahlenbiologie: Bedeutung inter- und intrazellulärer Signalketten; Apoptose, Zellzyklus-Checkpoints; Strahlensyndrome, Krebsrisiko, Krebsinduktion, Mutationsauflösung, pränatale Strahlenwirkung; Strahlensicherheitsmaßnahmen: Risiken-Abwägungen bei der medizinischen Strahlenanwendung; Prädispositionen in der Strahlenbiologie: Methoden der Optimierung der therapeutischen Strahlenanwendung.

Lecture notes
Beilagen mit zusammenfassenden Texten, Tabellen, Bild- und Grafikdarstellungen werden abgegeben.

Prerequisites
Literature

Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>465-0956-00L</td>
<td>Dosimetry</td>
<td>O</td>
<td>4</td>
<td>6G</td>
<td></td>
</tr>
</tbody>
</table>

Abstract
Dosimetry in radiotherapy. Planning and implementation of a percutaneous radiation exposure on an anthropomorphic phantom. Verification of the resulting dose distribution.

Objective
Praktische Umsetzung der Lerninhalte der Vorlesungen Medizinphysik I & II bezüglich Dosimetry bei perkutanen Strahlenexpositionen

Content
Dosimetrie in der Strahlentherapie, Planung und Durchführung einer perkutanen Strahlenexposition an einem anthropomorphen Phantom. Überprüfung der resultierenden Dosisverteilungen.

Lecture notes
Die Kursunterlagen werden im Blockkurs abgegeben.

Specialisation in General Medical Physics

Major in Radiation Therapy

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1516 of 2416
Abstract
Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.

Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

227-0943-00L Radiobiology W 2 credits 2V M. Pruschy

Abstract
The purpose of this course is to impart basic knowledge in radiobiology in order to handle ionizing radiation and to provide a basis for predicting the radiation risk.

Objective
By the end of this course the participants will be able to:
- interpret the 5 Rs of radiation oncology in the context of the hallmarks of cancer
- understand factors which underpin the differing radiosensitivities of different tumors
- follow rational strategies for combined treatment modalities of ionizing radiation with targeted agents
- understand differences in the radiation response of normal tissue versus tumor tissue
- understand different treatment responses of the tumor and the normal tissue to differential clinical-related parameters of radiotherapy (dose rate, LET etc.).

Content
Einführung in die Strahlenbiologie ionisierender Strahlen: Allgemeine Grundlagen und Begriffsbestimmungen; Mechanismen der biologischen Strahlenwirkung: Strahlenwirkung auf Zellen, Gewebe und Organe; Modifikation der biologischen Strahlenwirkung; Strahlenzytogenetik; Chromosomenveränderungen, DNA-Defekte, Reparaturprozesse; Molekulare Strahlenbiologie; Bedeutung inter- und intrazellulärer Signalübermittlungsprozesse, Apoptose, Zellzyklus-Checkpoints; Strahlenskribo: Strahlensyndrom, Krebsinduktion, Mutationssauslösung, pränatale Strahlenwirkung; Strahlenbiologische Grundlagen des Strahlenschutzes; Nutzen-Risiko-Abwägungen bei der medizinischen Strahlenanwendung; Prädictive strahlenbiologische Methoden zur Optimierung der therapeutischen Strahlenanwendung.

Prerequisites / notice
Voraussetzung: Besuch der Vorlesung Medizinische Physik I & II bezüglich Dosimetrie bei perkutanen Strahlenexpositionen

227-0956-00L

Abstract
Dosimetrie in der Strahlenanwendung. Prädiktive strahlenbiologische Methoden zur Optimierung der therapeutischen Strahlenanwendung.

Prerequisites / notice

3G

Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.

Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

465-0956-00L Dosimetry W 4 credits 6G

Abstract
Dosimetrie in radiotherapy. Planning and implementation of a percutaneous radiation exposure on an anthropomorphic phantom. Verification of the resulting dose distribution.

Objective
Praktische Umsetzung der Lerninhalte der Vorlesungen Medizin physik I & II bezüglich Dosimetrie bei perkutanen Strahlenexpositionen

Content
Dosimetrie in der Strahlentherapie. Planung und Durchführung einer perkutanen Strahlenexposition an einem anthropomorphen Phantom. Überprüfung der resultierenden Dosisverteilungen.

Prerequisites / notice
Die Kursunterlagen werden im Blockkurs abgegeben.

465-0800-00L Practical Work W 4 credits

Abstract
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

Objective
The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

3G

Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Prerequisites / notice
A script will be provided.

227-0965-00L Micro and Nano-Tomography of Biological Tissues W 4 credits 3G

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

227-0941-00L
Physics and Mathematics of Radiotherapy Planning
(University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: PHY471

Mind the enrolment deadlines at UZH:

Abstract
This lecture will provide a detailed introduction to radiotherapy treatment planning. The course considers the physical interactions of radiation in tissue, the mathematical aspects of treatment planning and additional aspects of central importance for radiotherapy planning.

Objective
Students shall develop a thorough understanding of the foundations of radiotherapy from a physics and mathematics perspective, focusing on algorithmic components. After completing the course students should be able to implement the main components of a radiotherapy treatment planning system.

Content
Radiotherapy is one of the main treatment options against cancer. Today, more than 50% of cancer patients receive radiation as part of their treatment. Modern radiotherapy is a highly technology driven field.

Research and development in medical physics has improved the precision of radiotherapy substantially. Using intensity-modulated radiotherapy (IMRT), radiation can be delivered precisely to tumors while minimizing radiation exposure of healthy organs surrounding the tumor. Thereby, medical physics has provided radiation oncologists with new curative treatment approaches where previously only palliative treatments were possible. This lecture will provide a detailed introduction to radiotherapy treatment planning and will consists of three blocks:

1. The first part of the course considers the physical interactions of radiation in tissue. The physical interactions give rise to dose calculation algorithms, which are used to calculate the absorbed radiation dose based on a CT scan of the patient.

2. The second part considers the mathematical aspects of treatment planning. Mathematical optimization techniques are introduced, which are used in intensity-modulated radiotherapy to determine the external radiation fields that optimally irradiate the tumor while minimizing radiation dose to healthy organs.

3. The third part deals with additional aspects of central importance for radiotherapy planning. This includes biomedical imaging techniques for treatment planning and target delineation as well as image registration algorithms.

The lectures are followed by computational exercises where students implement the main components of a radiotherapy treatment planning systems in two dimensions in Matlab.

Lecture notes
Lecture slides and handouts.

Prerequisites / notice
Basic programming skills in Matlab (or willingness to learn) are needed for the exercises. Basic knowledge of calculus is needed, approximately corresponding to the 3rd year of a bachelor degree in physics, mathematics, computer science, engineering or comparable discipline.

402-0674-00L
Physics in Medical Research: From Atoms to Cells

Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
Lecturers
ECTS
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Major in Biomechanics**

**Core Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs. In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**
- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.
- Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes**
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

**Prerequisites / notice**
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

| Social Competencies                   | Communication         | not assessed |
|                                       | Cooperation and Teamwork | not assessed |
|                                       | Customer Orientation   | not assessed |
|                                       | Leadership and Responsibility | not assessed |
|                                       | Self-presentation and Social Influence | not assessed |
|                                       | Sensitivity to Diversity | not assessed |
|                                       | Negotiation            | not assessed |

| Personal Competencies                 | Adaptability and Flexibility | not assessed |
|                                      | Creative Thinking          | not assessed |
|                                      | Critical Thinking          | not assessed |
|                                      | Integrity and Work Ethics  | not assessed |
|                                      | Self-awareness and Self-reflection | not assessed |
|                                      | Self-direction and Self-management | not assessed |

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**227-0965-00L Micro and Nano-Tomography of Biological Tissues**

**W** 4 credits 3G M. Stampanoni, F. Marone Welford

**Abstract**
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

**Objective**
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

**Content**
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

**Lecture notes**
Available online

**Literature**
Will be indicated during the lecture.

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**376-1651-00L Clinical and Movement Biomechanics**

W 4 credits 3G N. Singh, R. List, P. Schütz

**Abstract**
Measurement and modeling of the human movement during daily activities and in a clinical environment.

**Objective**
The students are able to analyse the human movement from a technical point of view, to process the data and perform modeling with a focus towards clinical application.

**Content**
This course includes study design, measurement techniques, clinical testing, accessing movement data and analysis as well as modeling with regards to human movement.

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**376-1985-00L Trauma Biomechanics**

W 4 credits 2V+1U K.-U. Schmitt, M. H. Muser

**Abstract**
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

**Objective**
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

**Lecture notes**
Handouts will be made available.

**Literature**
Practical Work

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>465-0800-00L</td>
<td>Practical Work</td>
<td>O</td>
<td>4 credits</td>
<td></td>
<td>external organisers</td>
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<tr>
<td>Abstract</td>
<td>The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.</td>
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<tr>
<td>Objective</td>
<td>The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.</td>
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Electives

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<tbody>
<tr>
<td>151-0524-00L</td>
<td>Continuum Mechanics I</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>A. E. Ehret</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.</td>
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<tr>
<td>Objective</td>
<td>Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.</td>
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<tr>
<td>Content</td>
<td>Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments</td>
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<tr>
<td>Lecture notes</td>
<td>The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The lecture will be taught in English.</td>
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<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<tr>
<td>Objective</td>
<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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<tr>
<td>Content</td>
<td>Main topics of the course include:</td>
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<td>Lecture notes</td>
<td>The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.</td>
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<td>Prerequisites / notice</td>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>376-2017-00L</td>
<td>Biomechanics of Sports Injuries and Rehabilitation</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>K.-U. Schmitt, J. Goldhahn</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture introduces the basic principles of injury mechanics and rehabilitation focussing on sports injuries. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.</td>
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<tr>
<td>Objective</td>
<td>Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.</td>
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<tr>
<td>Content</td>
<td>This lecture deals with the basic principles of injury mechanics and rehabilitation. Mechanisms that can result in injury are presented. Furthermore possibilities to prevent injuries are discussed. Thereby the lecture focuses on sports injuries.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>A course work is required. The mark of this course work contributes to the final credits for this lecture. Details will be given during the first lecture.</td>
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Major in Bioimaging

Core Courses

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1521 of 2416
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the tools of the biomedical engineering point of view.

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The course language is English.

Prerequisites: Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

Lecture notes: Course material Script, computer demonstrations, exercises and problem solutions

Practical Work

No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Prerequisites / notice

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

227-0447-00L Image Analysis and Computer Vision

W  6 credits  3V+1U  E. Konukoglu, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered.

The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed.

A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites / notice
Prerequisites:

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.

Practical Work

Number Title Type ECTS Hours Lecturers
465-0800-00L Practical Work O 4 credits external organisers
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

## Electives

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<th>Hours</th>
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<tbody>
<tr>
<td>151-0605-00L</td>
<td>Nanosystems</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>A. Stemmer</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.</td>
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<td><strong>Objective</strong></td>
<td>Familiarize students with basic science and engineering principles governing the nano domain. The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected. Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled. Topics are treated in 2 blocks: (I) From Quantum to Continuum From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. (II) Interaction Forces on the Micro and Nano Scale From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.</td>
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<tr>
<td><strong>Content</strong></td>
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<td>Prerequisites / notice</td>
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<td>Lectures and Mini-Review presentations: Thursday 10-13</td>
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<td>Homework: Mini-Review</td>
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<td>(compulsory continuous performance assessment)</td>
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<td>Each student selects a paper (listed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.</td>
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<td>227-0965-00L</td>
<td>Micro and Nano-Tomography of Biological Tissues</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Stampanoni, F. Marone Welford</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Literature</td>
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<tr>
<td>227-0967-00L</td>
<td>Computational Neuroimaging Clinic</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>K. Stephan</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This seminar teaches problem solving skills for computational neuroimaging, based on joint analyses of neuroimaging and behavioural data. It deals with a wide variety of real-life problems that are brought to this meeting from the neuroimaging community at Zurich, e.g. mass-univariate and multivariate analyses of fMRI/EEG data, or generative models of fMRI, EEG, or behavioural data.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Consolidation of theoretical knowledge (obtained in the following courses: 'Methods &amp; models for fMRI data analysis', 'Translational Neuroimaging', 'Computational Psychiatry') in a practical setting.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Literature</td>
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<td></td>
<td>Prerequisite: Successful completion of course &quot;Methods &amp; Models for fMRI Data Analysis&quot;, &quot;Translational Neuroimaging&quot; or &quot;Computational Psychiatry&quot;</td>
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<td>Will be indicated during the lecture.</td>
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</table>
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitations, for example, plasmon excitations. Both effects are perfectly described by dipole and impact scattering. Thin-films of complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

227-0969-00L Methods & Models for fMRI Data Analysis W 6 credits 4V K. Stephan

Abstract This course teaches methods and models for fMRI data analysis, covering all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, statistical inference, multiple comparison corrections, event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data.

Objective To obtain in-depth knowledge of the theoretical foundations of SPM and DCM and of their practical application to empirical fMRI data.

Content This course teaches state-of-the-art methods and models for fMRI data analysis in lectures and exercises. It covers all aspects of statistical parametric mapping (SPM), incl. preprocessing, the general linear model, frequentist and Bayesian inference, multiple comparison corrections, and event-related designs, and Dynamic Causal Modelling (DCM), a Bayesian framework for identification of nonlinear neuronal systems from neurophysiological data. A particular emphasis of the course will be on methodological questions arising in the context of clinical studies in psychiatry and neurology. Practical exercises serve to consolidate the skills taught in lectures.

402-0674-00L Physics in Medical Research: From Atoms to Cells W 6 credits 2V+1U B. K. R. Müller

Abstract Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitations, for example, plasmon excitations. Both effects are perfectly described by dipole and impact scattering. Thin-films of complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

227-2037-00L Physical Modelling and Simulation W 6 credits 4G J. Smajč

Abstract This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS. In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

Data: 01.11.2022 12:41 Autumn Semester 2022
Syrchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes
Available online

Literature
Will be indicated during the lecture.

376-1103-00L
Frontiers in Nanotechnology
W 4 credits 4V V. Vogel, further lecturers

Abstract
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within mammade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nano systems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

376-1714-00L
Biocompatible Materials
W 4 credits 3V K. Maniura, M. Rottmar, M. Zenobi-Wong

Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

(available online via ETH library)

Handouts and references therin.

636-0108-00L
Biological Engineering and Biotechnology
W 4 credits 3V M. Fussenegger

Abstract
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content

Lecture notes
Handout during the course.
### Practical Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>465-0800-00L</td>
<td>Practical Work</td>
<td>O</td>
<td>4 credits</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td><em>Only for MAS in Medical Physics</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Abstract**
The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

**Objective**
The practical work is aimed at training the student's capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

### Electives

376-1622-00L Practical Methods in Tissue Engineering (offered in the Autumn Semester) and 376-1624-00L Practical Methods in Biofabrication (offered in the Spring Semester) are mutually exclusive to be eligible for credits.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
</tbody>
</table>

**Abstract**
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

**Content**
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

**Lecture notes**
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

**Prerequisites / notice**
The lecture will be taught in English.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0386-00L</td>
<td>Biomedical Engineering</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong</td>
</tr>
</tbody>
</table>

**Abstract**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**
- History of BME and the role of biomedical engineers. Ethical issues related to BME.
- Biomedical sensors both wearable and also biochemical sensors.
- Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
- Bioinformatics: genomic and proteomic tools, databases and basic calculations.
- Equations describing basic reactions and enzyme kinetics.
- Medical optics: Optical components and systems used in hospitals.
- Basic concepts of tissue engineering and organ printing.
- Biomaterials and their medical applications.
- Function of the heart and the circulatory system.
- Transport and exchange of substances in the human body, compartment modeling.
- The respiratory system.
- Bioimaging.
- Orthopedic biomechanics.

Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes**
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

**Prerequisites / notice**
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Negotiation: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Biomineralization

Abstract
The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biomineralization.

Objective
The course aims to introduce the basic concepts of biomineralization and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.

Content
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM) / types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere / evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Prerequisites / notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

Practical Methods in Tissue Engineering

Abstract
Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice
A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

Physics in Medical Research: From Atoms to Cells

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the materials studied. Low-energy electrons lead to plasmon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

**Bioelectronics and Biosensors**

**Objective**

- learn about the remaining challenges in this field
- learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

**Abstract**

The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectric signals and the basic concepts to record optogenetically modified organisms are introduced.

During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

**Fostered competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Literature**


Lecture topics:

1. Introduction

Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Literature
Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Major in Bioelectronics

Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
</tbody>
</table>

Abstract
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
- Main topics of the course include:
  - Scaling laws at micro/nano scales
  - Electrostatics
  - Electromagnetism
  - Low Reynolds number flows
  - Observation tools
  - Materials and fabrication methods
  - Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

| 227-0386-00L | Biomedical Engineering | W    | 4 credits | 3G   | J. Vörös, S. J. Ferguson, S. Kozerke, M. P. Wolf, M. Zenobi-Wong |

Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined. Equations describing basic reactions and enzyme kinetics, Medical optics: Optical components and systems used in hospitals. Basic concepts of tissue engineering and organ printing. Biomaterials and their medical applications. Function of the heart and the circulatory system. Transport and exchange of substances in the human body, compartment modeling. The respiratory system. Bioimaging. Orthopedic biomechanics. Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

227-1037-00L Introduction to Neuroinformatics

Abstract

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

376-1714-00L Biocompatible Materials

Abstract

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.
Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.
A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature

(available online via ETH library)

Bioelectronics and Biosensors

227-0393-10L

W  6 credits  2V+2U  J. Vörös, M. F. Yanik

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content
Lecture topics:
1. Introduction
Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology
Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
14. Measuring biochemical signals

Lecture notes
A detailed script is provided to each lecture including the exercises and their solutions.

Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice
The course requires an open attitude to the interdisciplinary approach of bioelectronics.
In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will cover basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. The main objective is to prepare students to communicate more effectively across disciplinary boundaries, and to provide them with deep insights into the various communities that are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective frontiers.

### Practical Work

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>465-0800-00L</td>
<td>Practical Work</td>
<td>O</td>
<td>4</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td>Only for MAS in Medical Physics</td>
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</table>

#### Objective

The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1033-00L</td>
<td>Neurororphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indivert, S.-C. Liu</td>
</tr>
</tbody>
</table>

#### Prerequisites / Notice

- Registration to module INI404 at UZH.

#### Objective

Understanding the characteristics of neurorphic circuit elements.

#### Content

Neurorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Neurons are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers, static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina, silicon cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

#### Literature

- S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

- Prerequisites: Background in basics of semiconductor physics helpful, but not required.

### Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>J. Smajic</td>
</tr>
</tbody>
</table>

#### Objective

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions on the practical simulation work of the students.

#### Content

Understanding the characteristics of neuromorphic circuit elements.

#### Literature

- Analog VLSI Circuits and Principles; various publications.

- Prerequisites / Notice

Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

### Further Course Information

- Preference is given to students that require this class as an elective towards the solution of a focused problem.

### Practical Work

- The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization.

- Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

- The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

- Registration in this class requires the permission of the external organizers, and participation is limited to students that require this class as an elective towards the solution of a focused problem.

- The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization.

- Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

- The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

### Additional Information

- Data: 01.11.2022 12:41
- Autumn Semester 2022
- Page 1532 of 2416
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

We will investigate the theoretical concepts behind microfluidic device operation, the methods of microfluidic device manufacture and the application of microfluidic architectures to important problems faced in modern day chemical and biological experimentation. Projects will be performed in groups of between four and six students and will include both experimental and simulation aspects. Each group, under the guidance of a mentor, will plan and execute a novel research project. The results of this activity will be disseminated through an "academic-style" research article and a "conference-style" oral presentation. Course grades will be evaluated through both a written exam and the project grade.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broadband range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties

W 4 credits 3V M. Fussenegger

Abstract

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to

Objective

Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to

Content


Lecture notes

Handout during the course.

➤➤ Major in Neuroinformatics

➤➤➤ Core Courses

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
227-1037-00L | Introduction to Neuroinformatics | W | 6 credits | 2V+1U+1A | V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens

Abstract

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

### Objective
Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

### Content
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Weisel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world.

However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

The practical work is designed to train the students in the solution of a specific problem and provides insights in the field of the selected MAS specialization. Tutors propose the subject of the project, the project plan, and the roadmap together with the student, as well as monitor the overall execution.

The practical work is aimed at training the student’s capability to apply and connect specific skills acquired during the MAS specialization program towards the solution of a focused problem.

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate calculus, and probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

The participation in the course is subject to the following conditions:
1) The number of participants is limited to 120 students (MSc and PhDs).
2) Students must have taken the exam in Deep Learning (263-3210-00L) or have acquired equivalent knowledge.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.
Introductory Course in Neuroscience I (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: SPV0Y005

Mind the enrolment deadlines at UZH:

Abstract
The course gives an introduction to human and comparative neuroanatomy, molecular, cellular and systems neuroscience.

Objective
The course gives an introduction to the development and anatomical structure of nervous systems. Furthermore, it discusses the basics of cellular neurophysiology and neuropharmacology. Finally, the nervous system is described on a system level.

Content
1) Human Neuroanatomy I & II
2) Comparative Neuroanatomy
3) Building a central nervous system I & II
4) Synapses I & II
5) Glia and more
6) Excitability
7) Circuits underlying Emotion
8) Visual System
9) Auditory & Vestibular System
10) Somatosensory and Motor Systems
11) Learning in artificial and biological neural networks

Prerequisites / notice
For doctoral students of the Neuroscience Center Zurich (ZNZ).

Physical Modelling and Simulation

W 6 credits 4G J. Smajic

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

Systems Neuroscience (University of Zurich)

W 6 credits 2V+1U D. Kiper

Abstract
This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions.

Objective
To understand the basic concepts underlying perceptual, motor control and cognitive functions.

Content
Main emphasis sensory systems, with complements on motor and cognitive functions.

Lecture notes
None

Literature
"Principles of Neural Science", Kandel, Schwartz, and Jessel

Prerequisites / notice
None

Major in Biocompatible Materials

Core Courses

376-1622-00L Practical Methods in Tissue Engineering (offered in the Autumn Semester) and 376-1624-00L Practical Methods in Biofabrication (offered in the Spring Semester) are mutually exclusive to be eligible for credits.

Number Title Type ECTS Hours Lecturers
227-0965-00L Micro and Nano-Tomography of Biological Tissues W 4 credits 3G M. Stamparoni, F. Marone Welldorf

Abstract
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

Data: 01.11.2022 12:41   Autumn Semester 2022   Page 1537 of 2416
Content

Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

Lecture notes

Available online

Literature

Will be indicated during the lecture.

376-1622-00L Practical Methods in Tissue Engineering  W 5 credits 4P  M. Zenobi-Wong, S. J. Ferguson, S. Grad, S. Schürle-Finke

Abstract

The goal of this course is to teach MSc students the necessary skills for doing research in the fields of tissue engineering and regenerative medicine.

Objective

Practical exercises on topics including sterile cell culture, light microscopy and histology, and biomaterials are covered. Practical work on manufacturing and evaluating hydrogels and scaffolds for tissue engineering will be performed in small groups. In addition to practical lab work, the course will teach skills in data acquisition/analysis.

Prerequisites / notice

A Windows laptop (or Windows on Mac) is required for certain of the lab modules.

376-1714-00L Biocompatible Materials  W 4 credits 3V  K. Maniura, M. Rottnar, M. Zenobi-Wong

Abstract

Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective

The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content

Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes

Handouts are deposited online (moodle).

Literature


(available online via ETH library)

Practical Work

3V

Electives

Biominerualisation

The course addresses undergraduate and graduate students interested in getting introduced into the basic concepts of biominerualisation.

The course aims to introduce the basic concepts of biominerualisation and the underlying principles, such as supersaturation, nucleation and growth of minerals, the interaction of biomolecules with mineral surfaces, and cell biology of inorganic materials creation. An important part of this class is the independent study and the presentation of original literature from the field.
Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM)/ types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

1. Introduction and overview
2. Biominerals and their functions
3. Chemical control of biomineralization
4. Control of morphology: Organic templates and additives
5. Modern methods of investigation of BM
6. BM in matrices: bone and nacre
7. Vertebrate teeth
8. Invertebrate teeth
9. BM within vesicles: calcite of coccoliths
10. Silica
11. Iron storage and mineralization

Lecture notes
Script with more than 600 pages with many illustrations will be distributed free of charge.

Literature
3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

Prerequisites / notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.
Objective

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

<table>
<thead>
<tr>
<th>227-0393-10L</th>
<th>Bioelectronics and Biosensors</th>
<th>W</th>
<th>6 credits</th>
<th>2V+2U</th>
<th>J. Vörös, M. F. Yanik</th>
</tr>
</thead>
</table>

Abstract

The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective

During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Content

Lecture topics:

1. Introduction

Sources of bioelectronic signals
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley

Measuring bioelectronic signals
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
10. Measuring mechanical signals with bioelectronics
11. Measuring biochemical signals
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy
14. Measuring biochemical signals

Lecture notes

A detailed script is provided to each lecture including the exercises and their solutions.

Literature

Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

Prerequisites / notice

The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
**Fostered competencies**

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

**Nanostructured Materials Safety**

W 2 credits 1V P. Wick

**Abstract**
Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection

**Objective**
Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials

**Lecture notes**
Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website

**Course “Introduction to Toxicology”**

**Core Courses**

**Number** 227-0945-00L

**Title** Cell and Molecular Biology for Engineers I

**Type** W 3 credits 2G

**ECTS**

**Hours** to be announced

**Lecturers**

**Abstract**
The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

**Objective**
After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

**Content**
Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

**Lecture notes**
Scripts of all lectures will be available.

**Literature**
The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Computational Biology
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Attendees will apply these concepts to a number of applications yielding biological insight into:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics
- epidemiology
- pathogen evolution
- macroevolution of species

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

**Practical Work**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>465-0800-00L</td>
<td>Practical Work Only for MAS in Medical Physics</td>
<td>O</td>
<td>4</td>
<td></td>
<td>external organisers</td>
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**Electives**

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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>327-1101-00L</td>
<td>Biomineralization</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>K.-H. Ernst</td>
</tr>
</tbody>
</table>
Content

Biomineralization is a multidisciplinary field. Topics dealing with biology, molecular and cell biology, solid state physics, mineralogy, crystallography, organic and physical chemistry, biochemistry, dentistry, oceanography, geology, etc. are addressed. The course covers definition and general concepts of biomineralization (BM) / types of biominerals and their function / crystal nucleation and growth / biological induction of BM / control of crystal morphology, habit, shape and orientation by organisms / strategies of compartmentalization / the interface between biomolecules (peptides, polysaccharides) and the mineral phase / modern experimental methods for studying BM phenomena / inter-, intra, extra- and epicellular BM / organic templates and matrices for BM / structure of bone, teeth (vertebrates and invertebrates) and mollusk shells / calcification / silification in diatoms, radiolaria and plants / calcium and iron storage / impact of BM on lithosphere and atmosphere/ evolution / taxonomy of organisms.

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Lecture notes
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Literature
3) P. M. Dove, J. J. DeYoreo, S. Weiner (Eds.) Biomineralization, Reviews in Mineralogy & Geochemistry Vol. 54, 2003

Prerequisites / notice
No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

376-1103-00L Frontiers in Nanotechnology
W 4 credits 4V V. Vogel, further lecturers

Abstract
Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective
Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content
Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes
All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

402-0674-00L Physics in Medical Research: From Atoms to Cells
W 6 credits 2V+1U B. K. R. Müller

Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitaxial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocyte behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxidic and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultraviolet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurement. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

### Literature

**535-0423-00L**  
**Objective**  
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

**Content**  
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

**Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.**

**551-1615-00L**  
**Objective**  
Introduction and discussion of advanced methods for recording and analysis of NMR data with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.

**Content**  
Seminar series on technical aspects of high-resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.

**551-0307-00L**  
**Objective**  
Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td></td>
</tr>
<tr>
<td>Techniques and Technologies</td>
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<tr>
<td>Analytical Competencies</td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<td>Project Management</td>
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**Method-specific Competencies**

<table>
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<tr>
<th>Social Competencies</th>
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<tbody>
<tr>
<td>Communication</td>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<tr>
<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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**Personal Competencies**

<table>
<thead>
<tr>
<th>Adaptability and Flexibility</th>
<th>Assessed</th>
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</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>Not Assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>Assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

**Drug Delivery and Drug Targeting**

<table>
<thead>
<tr>
<th>535-0423-00L</th>
<th>W 2 credits 1.5V J.-C. Leroux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.</td>
</tr>
<tr>
<td>Objective</td>
<td>The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the change and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.</td>
</tr>
<tr>
<td>Content</td>
<td>The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems. Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.</td>
</tr>
<tr>
<td>Literature</td>
<td></td>
</tr>
</tbody>
</table>

**551-1615-00L**  
**Prerequisites:** Basic knowledge in biological NMR spectroscopy.

<table>
<thead>
<tr>
<th>NMR Methods for Studies of Biological Macromolecules</th>
<th>W 1 credit 2S A. D. Gossert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Seminar series on technical aspects of high resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.</td>
</tr>
<tr>
<td>Objective</td>
<td>Seminar series on technical aspects of high-resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.</td>
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<tr>
<td>Content</td>
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</tr>
</tbody>
</table>

**551-0307-00L**  
**D-BIOL students are obliged to take part I and part II (next)**

<table>
<thead>
<tr>
<th>Molecular and Structural Biology I: Protein Structure and Function</th>
<th>W 3 credits 2V R. Glockshuber, K. Locher, E. Weber-Ban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Seminar series on technical aspects of high-resolution nuclear magnetic resonance (NMR) spectroscopy with biological macromolecules. This seminar series is targeted at Master students and PhD students conducting research projects in the field of biomolecular NMR in solution.</td>
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<td>Content</td>
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</tr>
</tbody>
</table>
Courses outside the curriculum

Abstract
Biophysics of protein folding, membrane proteins and biophysics of membranes, enzymatic catalysis, catalytic RNA and RNAi, current topics in protein biology and structural biology.

Objective
Understanding of structure-function relationships in proteins and in protein folding, detailed understanding of biophysics and physical methods as well as modern methods for protein purification and microanalytics.

Lecture notes
Scripts on the individual topics can be found under http://www.mol.biol.ethz.ch/teaching.

Literature
Basics:
- Creighton, T.E., Proteins, Freeman, (1993)
- Fersht, A., Enzyme, Structure and Mechanism in Protein Science (1999), Freeman.

Current topics: References will be given during the lectures.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Semester</th>
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<tbody>
<tr>
<td>636-0108-00L</td>
<td>Biological Engineering and Biotechnology</td>
<td>W</td>
<td>4 credits</td>
<td>V</td>
</tr>
<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W</td>
<td>6 credits</td>
<td>G</td>
</tr>
</tbody>
</table>

**Biological Engineering and Biotechnology**

Abstract
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Objective
Biological Engineering and Biotechnology will cover the latest biotechnological advances as well as their industrial implementation to engineer mammalian cells for use in human therapy. This lecture will provide forefront insights into key scientific aspects and the main points in industrial decision-making to bring a therapeutic from target to market.

Content

**Physical Modelling and Simulation**

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

**MAS in Medical Physics - Key for Type**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

**Key for Hours**

<table>
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<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Future Transport Systems

Four-semester, part-time MAS programme.


▶ Major in Systemic Aspects of Future Transport

The Major in “Systemic Aspects of Future Transport” takes place every 1.5 years according to the program website.

Start of the next course: Spring Semester 2024

Course duration: Six months part time

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>166-0100-00L</td>
<td>Transport Systems: Dynamics and Future Developments</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Erath Rusterholtz, J. Schippl</td>
</tr>
</tbody>
</table>


Abstract

Interrelationships and dynamic change and the impact of these on mobility and transportation are being investigated in this module. The module addresses desirable future development of urban transport systems in Switzerland by covering and critically examining authentic, existing transport scenarios (e.g. ARE) in an exercise setting which deploys backcasting.

Objective

Participants
- understand the complexity of the transport system status quo as a whole, and are able to describe it qualitatively and create an operational and/or working context (K1).
- understand the development of transport systems and future transport scenarios over time, and can infer objectives from the latter (K2).
- understand the dynamics between spacial quality and mobility behavior and can evaluate how measures to promote active mobility can contribute to a more sustainable transport system (K3).
- understand how digitalisation drives new mobility services (mobility as a service), and are able to qualitatively estimate the changes these bring to transport systems as a whole (K4).
- are able to pinpoint the challenges and potential of the transition to autonomous transport forms (K5).

Content

- Deepen understanding of complex transport systems and their dynamics past – status quo – future
- Consolidate a foundation in the dynamics of transport systems: elements and their interrelationships
- Overview and selection of methods/approaches for the development and analysis of scenarios
- Future perspectives (ARE), target scenarios
- Transformation and change in systems
- Transport policy and the potential of regulation
- Excursion: “Infrastructure to support active mobility: Bike capital Bern”

Methods selected
- System analysis, scenario analysis, foresight, indicators for sustainable mobility, Case studies, reading and discussion of thesis papers and scientific publications

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

166-0101-00L | Development and Assessment of Transport Scenarios | O    | 3 credits | 3G   | A. Erath Rusterholtz |


Abstract

This module familiarises participants with current methods of developing and evaluating transport scenarios. These include analysis of the interrelationship of space and traffic; traffic modelling methods; and evaluation according to economic and planning criteria.

Objective

Participants
- are familiar with suitable methods for developing transport scenarios and how to analyse and evaluate them. In particular, they know how to address the challenges of evaluating future forms of transport;
- are able to select a suitable method and determine an evaluation concept with relation to a specific problem.

Content

- Methodological foundations of traffic modelling (44-level model, activity-based model,agent-based simulation)
- Design and evaluation of transport scenarios using MATSim (traffic simulation) with a focus on transport with autonomous vehicles
- Interrelationship of space and traffic (accessibility measurement, settlement density and mixed usage) and what to consider in designing and evaluating transport scenarios
- Approaches to evaluation of traffic scenarios (cost-benefit analyses and their foundations, methodological limits), analysis of effects taking into account user group and space type
- Ecobalancing with Life Cycle Assessment (LCA) in addressing passenger and goods transport issues
- Development of case studies on shared transport and mobility with an activity- and agent-based transport simulation model

Methods
- Aggregated and activity-based transport demand models
- Agent-based simulation
- Cost-benefit analysis
- Accessibility analysis

Case studies
- Shared mobility
- Autonomous mobility
- Densified settlement development and slow forms of mobility

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term.

166-0102-00L | Foundations for the Design of Transport System Innovation and Change Processes | O    | 3 credits | 2G   | J. Schippl |


Abstract

Deal with a specific problem from the CAS System Aspects subject area.

Participants are able...
- to understand the economic and social-science fundamentals of innovation and change processes in the area of transportation;
- to analyse the foundations, opportunities and challenges of disruption in mobility systems;
- to set these concepts and frameworks in context to pathways towards more sustainable mobility;
- and to set these concepts and frameworks constructively in context to their own work practice.

In this module, innovation, change and transitions in transportation systems on different levels are discussed from different complementary perspectives. Both economic and social science approaches to the analysis, anticipation and governance of innovation processes are presented, discussed and applied to current issues. Topics are:
- Respective theories and methods;
- Innovation as an economic discovery process, measuring innovation;
- Emerging trends as new opportunities for innovation;
- Innovation today in the transportation/mobility system: theoretical basis and concrete examples;
- Transition of socio-technical systems, co-evolution of technical and societal dynamics;
- The relevance of social acceptance and ethical aspects for innovations in mobility.

Date: 01.11.2022 12:41 Autumn Semester 2022 Page 1547 of 2416
### Prerequisites / notice

**166-0201-00L** Potential of Spatial Information- and Communication Technologies  
**O** 3 credits 3G  

*Does not take place this semester.*  

**Abstract**  
The digital revolution, spatial information and communication systems in particular, have a significant influence on the development of new transport systems. Participants acquire an in-depth understanding of the functionality and application potential of spatial information systems and services and of communication technologies for deployment in future transport systems and applications.  

**Objective**  
Familiarity with information and communication technologies (ICT) and spatial information technologies, and the ability to identify and utilise their potential to address concrete problems.  

**Content**  
- Functionality and application of geographic information systems (GIS) to represent and analyse transport systems (acquire, model, analyse and visualise geodata)  
- Deployment potentials of GIS and ICT for efficient transport solutions (tangible, non-tangible)  
- Functionality and application of mobile spatial information technologies in future transport systems  
- Methods of spatiotemporal analysis and geodata analysis  
- Technical aspects of information and communication technologies (ICT)  
- Modelling, simulation and assessment of traffic behaviour  
- Basics of autonomous driving  
- Legal aspects of geodata  
- Applications: Traffic behaviour in Switzerland; location based services for energy-efficient behaviour; GIS for the Zurich traffic system (multimodal)

**Lecture notes**  
Distributed at start of module  

**Literature**  
Distributed at start of module  

**Prerequisites / notice**  
Announced to students of the of the MAS / CAS at the beginning of the term.

**166-0202-00L** Integrated Assessment of Technologies and Transport Systems  
**O** 2 credits 1G  

*Does not take place this semester.*  

**Abstract**  
The module provides a solid introduction to integrated technology assessment with regard to economic, ecological and social criteria. It introduces life cycle assessment (LCA), cost assessment, risk assessment and multi-criteria decision analysis. It also presents scenario analyses based upon energy-economic models which explicitly represent transport and energy-supply technologies.  

**Objective**  
An overview of suitable methods for analysing and evaluating technical systems (transport systems) and the ability to choose among them to address concrete problems  

**Content**  
1. Introduction to and overview of integrated assessment  
   - Current status of transport in Switzerland and internationally  
   - Scope and goals of integrated assessment  
   - Sustainability: concept and practical implementation via criteria and indicators  
   - Overview of concepts and implementation methods

2. Selected methods for assessing transport technologies and their application to current and future options  
   - Ecobalance / life cycle assessment (LCA)  
   - Location-specific assessment of health hazards and environmental pollution  
   - Risk analysis  
   - Internal cost assessment  
   - External cost assessment

3. Integrated assessment of transport technologies  
   - Overall costs (internal and external)  
   - Multi-criteria analysis

4. Analysis of transport scenarios  
   - Scenarios, influencing factors, policy and sustainability  
   - Approaches to scenario modelling  
   - Global mobility scenarios: examples  
   - Transport scenarios for Switzerland using energy system models

**Lecture notes**  
Distributed at start of module  

**Literature**  
Distributed at start of module  

**Prerequisites / notice**  
Announced to students of the of the MAS / CAS at the beginning of the term.

**166-0203-00L** Energy Carrier for the Mobility of the Future  
**O** 3.5 credits 3G  

*Does not take place this semester.*  

**Abstract**  
The module includes the supply of the road mobility of the future with renewable energy. The generation, transport, processing, transfer of energy to the vehicles (refueling, charging) and the energetic evaluation are presented. Electricity, hydrogen, biogenic and synthetic fuels are considered.  

**Objective**  
The aim of the module is a detailed energetic and technical understanding of the supply of road vehicles with renewable energy. Graduates know the primary energy production as well as the end energy processing of the different energy carrier concepts. In addition, they know the legal CO2 requirements for vehicle registration and are able to qualitatively assess the impact on the Swiss energy system.  

**Content**  
- The energy system of the future; biogenic and electric renewable primary energy  
- End energy processing  
- Transfer from the energy system to mobility and influences on the overall energy system

**Lecture notes**  
Distributed at start of module  

**Literature**  
Distributed at start of module  

**Prerequisites / notice**  
Announced to students of the of the MAS / CAS at the beginning of the term.

**166-0290-00L** CAS Thesis on Technology Potentials  
**O** 3 credits 5D  

*Does not take place this semester.*  

M. A. Streicher-Porte

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Data: 01.11.2022 12:41  
Autumn Semester 2022  
Page 1548 of 2416
Abstract
The participants, in heterogeneous teams, deal with a current problem from the topics of the CAS Technology Potentials.

Objective
- Deal with a specific problem from the CAS Technology Potentials subject area.
- Be able to work interdisciplinary and across sectors, where appropriate together with relevant other parties.
- Communicate the results appropriately.

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS / CAS at the beginning of the term

► Major in New Business Models

The Major in "New Business Models" takes place only in Spring Semester

Start of the next course: Spring Semester 2023
Course duration: Six months part time
Periodicity: yearly

► Major in Transport Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>149-0001-00L</td>
<td>Transport Planning - Theory and Models</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>K. W. Axhausen</td>
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<td>Only for CAS in Transport Engineering and MAS in Future Transport Systems</td>
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<tr>
<td>149-0002-00L</td>
<td>Traffic Engineering</td>
<td>W</td>
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► Additional Task MAS|CAS

Depending on the need, the "Additional task MAS|CAS" Module takes place every Semester.

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>166-0002-00L</td>
<td>Additional Task MAS/CAS</td>
<td>O</td>
<td>1</td>
<td>2A</td>
<td>M. A. Streicher-Porte</td>
</tr>
<tr>
<td></td>
<td>Only for MAS in Future Transport Systems.</td>
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</tbody>
</table>

Abstract
Independent deepening studies on a defined field within MAS.

Objective
Compensatory task due to regulation changes / Independent deepening studies on a defined field within MAS.

Lecture notes
Zu Beginn des Moduls abgegeben.

Literature
Zu Beginn des Moduls abgegeben.

Prerequisites / notice
Werden an Studierende des MAS/CAS bis Semesterstart bekannt gegeben.

► Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>166-0490-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>15</td>
<td>27D</td>
<td>M. A. Streicher-Porte</td>
</tr>
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<td>Only for MAS in Future Transport Systems.</td>
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</table>

Abstract
Individually and independently, students address a practice-related problem in the area of future transport systems. To do this they deploy, under the supervision of an expert, what they have learned in the MAS programme. They set out the problem, the procedure and the solution in a written report which they present and defend in front of a specialist audience.

Objective
- Ability to draw up solutions in the context of future transport systems.
- Ability to communicate these solutions in a manner suited to a particular target audience.

Content
- Introductory colloquium: Working scientifically and presenting a project idea
- Individual and independent work on a problem selected by the participant
- Interim colloquium: Presentation of the status quo
- Individual supervision by the lecturer
- compilation of the written thesis and preparation of the presentation
- Examination colloquium: Presentation and defence

Lecture notes
Distributed at start of module

Literature
Distributed at start of module

Prerequisites / notice
Announced to students of the of the MAS at the beginning of the term.

MAS in Future Transport Systems - Key for Type

<table>
<thead>
<tr>
<th></th>
<th>Compulsory</th>
<th>Recommended, not eligible for credits</th>
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<tbody>
<tr>
<td>O</td>
<td>E-</td>
<td>Z</td>
</tr>
<tr>
<td>W+</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
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<th>G</th>
<th>U</th>
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<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>P</td>
<td>A</td>
<td>D</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Lecture with exercise</td>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Lectures and Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>115-0510-00L</td>
<td>Lecture Week 10: Spatial Development</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>M. Nollert, J. Van Wezemael</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td></td>
<td>In this course, the fundamental methods in spatial planning learned in the first week, in particular regarding planning methodology, spatial design and argumentation are consolidated in lectures and case studies.</td>
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<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The aim of the lecture is the consolidation and the practice of important methodic principles in spatial planning. They provide a basis also for the work in the second Study Project of the MAS program.</td>
</tr>
<tr>
<td>115-0511-00L</td>
<td>Lecture Week 11: Urban Planning and Urban Design II</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>S. Kretz, to be announced</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The second week on urban design and urban planning focuses on a case study in the field of strategic urban design. The course includes lectures, discussions, methodological inputs and a design workshop. Students analyze and discuss a real life problem and elaborate proposals for a suitable urban design strategy.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>The aim of the course is an in-depth understanding of contemporary urban design challenges and an exemplary, case-based experience of elaborating adequate urban design strategies.</td>
</tr>
<tr>
<td>115-0512-00L</td>
<td>Lecture Week 12: Spatial Planning: Theory and Methodology</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>A. Voigt</td>
</tr>
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<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Impart thinking patterns and active application of fundaments of planning theories and methods. The main focus is on plausibility and rigor of reasoning in spatial planning, from problem definition and analysis of its causes to the formulation of robust solutions; development of different planning steps considering communication theory and ethical aspects.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td></td>
<td>Autonomous and productive application of analyzed thinking patterns and planning steps; situationally appropriate and task-oriented transfer to new planning problems.</td>
</tr>
<tr>
<td>115-0513-00L</td>
<td>Lecture Week 13: Academic Working in Spatial Planning</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>R. Nebel, A. Rupf</td>
</tr>
<tr>
<td></td>
<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Understanding what scientific work means in spatial planning. Procedures for clarification processes; basics of scientific working and writing; case studies and exercises.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
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<td></td>
<td>Knowledge for a scientific way of working; structuring a scientific paper using the example of the DAS Synopsis or MAS Thesis.</td>
</tr>
<tr>
<td>115-0514-00L</td>
<td>Lecture Week 14: Spatial Planning: International Aspects</td>
<td>W</td>
<td>2</td>
<td>1G</td>
<td>F. Persyn</td>
</tr>
<tr>
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<td>Only for MAS, DAS and CAS in Spatial Planning.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Introduction to international perspectives in spatial planning. Exploring various scales and their interconnectedness as well as flows and practices that bridge different cultures of planning. International competitions as a tool to navigate different planning realities, terrains and transformations. Team work on an ongoing case.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Learning from different spatial planning cultures, their interaction and improving the capacity to understand and bring solutions to diverse planning contexts.</td>
</tr>
<tr>
<td>115-0702-02L</td>
<td>Introduction Study Project 2</td>
<td>O</td>
<td>1</td>
<td>1G</td>
<td>J. Van Wezemael, A. Rupf</td>
</tr>
<tr>
<td></td>
<td>Only for MAS in Spatial Planning</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>The subject of the study project in the second year is the dependency between surface and subsurface in spatial planning. The topic, clarification of potentials and missing instruments, legal situation in spatial planning are highly topical. Excursion to existing projects and with guided tours and presentations, consolidation of the bases for interdisciplinary group work.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>The aim of the first course in the second year of the program is a personal position determination in the framework of the continuing education program, the developing of an overview on the second study project and reviewing the basic knowledge regarding interdisciplinary teamwork gathered in the first year, adapting it if necessary in the second year.</td>
</tr>
</tbody>
</table>

### Projects and Individual Work

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>115-0702-00L</td>
<td>Study Project 2 (Part 1)</td>
<td>O</td>
<td>0</td>
<td>10U</td>
<td>M. Nollert, F. Argast, O. Hagen, R. Klostermann, A. Nål-Classen, J. Van Wezemael</td>
</tr>
<tr>
<td></td>
<td>Only for MAS in Spatial Planning.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td></td>
<td>Conceiving strategies for sustainable spatial development in the Geneva Lake-Fribourg-Bern region: spatial planning analysis of the situation (goals and problems, potentials and risks, strengths and weaknesses); concept design (goals and measures); program development (objective and temporal priorities); preparation for implementation (instruments and proceedings); independent team work.</td>
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<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Detecting and assessing crucial issues of spatial development and identifying requested planning action. Concentrate resources, evaluate different solution concepts and demonstrate their feasibility exemplarily. Recognizing possibilities and limits of formal and informal planning and apply them in practice. Efficient interdisciplinary team work, making optimal use of individual knowledge and skills of team members.</td>
</tr>
</tbody>
</table>

### MAS in Spatial Planning - Key for Type

| W+            | Eligible for credits and recommended       | Z    | Courses outside the curriculum |
| W             | Eligible for credits                       | Dr   | Suitable for doctorate         |
| E-            | Recommended, not eligible for credits      | O    | Compulsory                     |
Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
**MAS in Sustainable Water Resources**

The Master of Advanced Studies in Sustainable Water Resources is a 12 month full time postgraduate diploma programme. The focus of the programme is on issues of sustainability and water resources in Latin America, with special attention given to the impacts of development and climate change on water resources. The programme combines multidisciplinary coursework with high level research. Sample research topics include: water quality, water quantity, water for agriculture, water for the environment, adaptation to climate change, and integrated water resource management.

Language: English. Credit hours: 66 ECTS.

For further information please visit: http://www.mas-swr.ethz.ch/

**Core Courses**

Foundation courses: 12 credits have to be achieved.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>118-0101-00L</td>
<td>Water Resources Seminars</td>
<td>O</td>
<td>3</td>
<td>3S</td>
<td>D. Molnar, A. Costa</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 16.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The Seminar Series features invited experts from a wide range of disciplines who present their experiences working with water related topics in Swiss and international settings. The students are exposed to different perspectives and are asked to apply the information they learn to specific case studies.</td>
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<tr>
<td>Objective</td>
<td>The Seminar Series provides students with background information on a wide range of topics related to water resources. Invited experts challenge the students to consider water resources and water resource management in new ways, using tools that have been successfully implemented in real case scenarios. The seminars include theory, case studies, and interactive discussions with the experts.</td>
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<tr>
<td>Content</td>
<td>The Seminar Series is aimed at offering students the opportunity to learn about water resources in a multi-disciplinary fashion, with a focus on Swiss and international examples. Selected topics include: Water &amp; Climate Change, Water &amp; Sanitation, Water Management in Central Asia, Water &amp; Agriculture, Nature Based Solutions, Water Hazards (floods), Water &amp; Business, and Water Stewardship. For additional details see the course website <a href="https://mas-swr.ethz.ch/curriculum/courses/core-courses/water-resources-seminars.html">https://mas-swr.ethz.ch/curriculum/courses/core-courses/water-resources-seminars.html</a>.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>For further information, contact Dr. Darcy Molnar (<a href="mailto:darcy.molnar@ifu.baug.ethz.ch">darcy.molnar@ifu.baug.ethz.ch</a>)</td>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
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<tr>
<td>118-0114-00L</td>
<td>Nature-Based Solutions and Blue Green Infrastructure</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>D. Molnar, P. M. Bach</td>
</tr>
<tr>
<td></td>
<td>Number of participants mandatory.</td>
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<tr>
<td>Abstract</td>
<td>Nature-based solutions (NbS) are effective means of addressing global societal challenges such as the need for water and food security, disaster risk reduction, and adaptation to climate change. Students are exposed to a variety of topics around NbS and Blue Green Infrastructure, gaining insight into how societies can incorporate ecosystem-based solutions to become more resilient and sustainable.</td>
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<tr>
<td>Objective</td>
<td>Nature-based solutions leverage water resources management to not only provide basic water servicing needs, but also a range of ecosystem services for the benefits of humans and the environment. At the urban and peri-urban level, multi-functional Blue Green Infrastructure solutions (inspired by nature-based concepts) are being developed that involve a broad range of stakeholders and a complex policy environment. The course will provide students with an overarching picture of how Nature-based solutions and Blue Green infrastructure are being used to make societies and cities greener, more resilient, climate-adaptive, more liveable, sustainable, and especially, how water resources management is being leveraged to accomplish this. Students will gain insight into suitable tools and approaches to navigating interactions between relevant stakeholders, hands-on experience through a scenario-based real-world project, a field visit to an urban case study, as well as insights from leading public and private sector experts in Nature-based Solutions and Blue Green Infrastructure.</td>
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<tr>
<td>Content</td>
<td>The course is designed to expose students to different ways of thinking across multiple disciplines, but with a focus on how, as future professionals, they can facilitate and provide tangible solutions that are multi-functional and accepted by a wide array of decision-makers. Selected topics include: (1) understanding how Nature-based solutions and Blue Green Infrastructure can be used to address global societal challenges, (2) understanding the need for different levels of planning in order to design effective solutions and policies that will ensure sustainable development, (3) identifying and understanding the function of suitable infrastructure to complement existing systems, (4) support tools and quantitative approaches for evidence-based performance evaluation, and (5) planning and decision-making around Nature-based solutions.</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>There is no textbook. Learning materials consist of lectures, videos, and references provided by the instructors on the course Moodle page.</td>
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</tr>
<tr>
<td>Literature</td>
<td>Literature consists of research papers and journal articles provided by the instructors on the course Moodle page.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Bachelor or Master studies in environmental engineering, environmental sciences, or architecture/urban planning. For further information, contact the MAS coordinator, Darcy Molnar (<a href="mailto:darcy.molnar@ifu.baug.ethz.ch">darcy.molnar@ifu.baug.ethz.ch</a>)</td>
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**Foundation Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0287-00L</td>
<td>River Basin Erosion</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>P. Molnar</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.</td>
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<tr>
<td>Objective</td>
<td>The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.</td>
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<tr>
<td>Content</td>
<td>The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.</td>
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<tr>
<td>Lecture notes</td>
<td>There is no script.</td>
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</tr>
<tr>
<td>Literature</td>
<td>The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>101-0267-01L</td>
<td>Numerical Hydraulics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Holzner</td>
</tr>
<tr>
<td>Abstract</td>
<td>In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.</td>
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</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1552 of 2416
Objective: The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.

Content: The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

All methods discussed are applied pratically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Lecture notes: Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

Literature:

102-0227-00L Systems Analysis and Mathematical Modeling in Urban Water Management
Number of participants limited to 50.


Objective: The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

Content:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

Lecture notes: Copies of overheads will be made available.

Literature: There will be a required textbook that students need to purchase:
Studends should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed

- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

102-0217-00L Process Engineering Ia

Abstract: Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective: Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

Content:
- Stoichiometry
- Microbial transformation processes
- Introduction to design and modeling of activated sludge processes
- Anaerobic processes, industrial applications, sludge stabilization

Literature: There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice: For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html
Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management not assessed
Social Competencies

Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed
Personal Competencies

Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

102-0617-00L Basics and Principles of Radar Remote Sensing for Environmental Applications

W 3 credits 2G I. Hajnsek

Abstract

The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

Objective

The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. At the end of the course the student has the understanding of
1. SAR basics and principles,
2. SAR polarimetry,
3. SAR interferometry and
4. environmental parameter estimation from multi-parametric SAR data

Content

The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:
1. Introduction into SAR basics and principles
2. Introduction into electromagnetic wave theory
3. Introduction into scattering theory and decomposition techniques
4. Introduction into SAR interferometry
5. Introduction into polarimetric SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

Lecture notes

Handouts for each topic will be provided

Literature

First readings for the course:
Complete literature listing will be provided during the course.

102-0215-00L Urban Water Management II

W 4 credits 2G M. Maurer, P. Staufer

Abstract


Objective

Consolidation of the basic procedures for design and operation of technical networks in water engineering.

Content

Demand Side Management versus Supply Side Management
Optimierung von Wasserverteilnetzen
Kalkausfällung, Korrosion von Leitungen
Hygiene in Verteilsystemen
Siedlungshydrologie: Niederschlag, Abflussbildung
Instationäre Strömungen in Kanalisationen
Stofftransport in der Kanalisation
Einleitbedingungen bei Regenwetter
Versickerung von Regenwasser
Generelle Entwässerungsplanung (GEP)

Lecture notes

Written material will be available digital.

Prerequisites / notice

Prerequisite: Introduction to Urban Water Management
Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Self-presentation and Social Influence not assessed

Personal Competencies
Sensitivity to Diversity not assessed
Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

701-1253-00L Analysis of Climate and Weather Data W 3 credits 2G C. Frei

Abstract
An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.

Objective
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.

Content
The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

Lecture notes
Documentation and supporting material:
- slides used during the lecture
- exercise sets and solutions
- R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

Literature
For complementary reading:

Prerequisites / notice
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

651-4031-00L Geographic Information Systems W 3 credits 4G A. Baltensweiler, M. Hägeli-Golay

Abstract
Introduction to the architecture and data processing capabilities of geographic information systems (GIS). Practical application of spatial data modeling and geoprocessing functions to a selected project from the earth sciences.

Objective
Knowledge of the basic architecture and spatial data handling capabilities of geographic information systems.

Content
Theoretical introduction to the architecture, modules, spatial data types and spatial data handling functions of geographic information systems (GIS). Application of data modeling principles and geoprocessing capabilities using ArcGIS: Data design and modeling, data acquisition, data integration, spatial analysis of vector and raster data, particular functions for digital terrain modeling and hydrology, map generation and 3D-visualization.

Lecture notes
Introduction to Geographic Information Systems, Tutorial: Introduction to ArcGIS Pro

Literature


102-0468-10L Watershed Modelling W 6 credits 4G P. Molnar

Abstract
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Literature

Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice

Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
- Method-specific Competencies
  - Writing simple functions;
  - Types of data: numeric, character, logical and categorical data, missing values;
  - Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

Objective

The students will be able to use the software R for simple data analysis and graphics.

Content

The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge number of packages that allow independent work.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org.

Note: Part I of UsingR is complemented and extended by Part II, which is offered during the second part of the semester and which can be taken independently from Part I.

Lecture notes

There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Lecture notes

An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

https://moodle-app2.let.ethz.ch/course/view.php?id=18279

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
- Method-specific Competencies
  - Writing simple functions;
  - Types of data: numeric, character, logical and categorical data, missing values;
  - Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

Elective Courses

Electives: 6 credits has to be achieved.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-6215-00L</td>
<td>Using R for Data Analysis and Graphics (Part I)</td>
<td>W</td>
<td>1.5 credits</td>
<td>1G</td>
<td>M. Mächler</td>
</tr>
</tbody>
</table>

The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

The course resources will be provided via the Moodle web learning platform. Subscribing via Mystudies "automatically" makes you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=18279

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Media and Digital Technologies
  - Problem-solving
- Social Competencies
  - Communication
  - Cooperation and Teamwork
- Personal Competencies
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

651-4077-00L | Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich) | W | 3 credits | 1V | University lecturers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO815

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmssss/en/studies/application/deadlines.html

Abstract

Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

Objective

Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.
Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

### Literature

A list of relevant literature is available on Moodle

### Prerequisites / notice

Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes in skript

### 651-4101-00L Physics of Glaciers

**Abstract**

Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A special focus is the current development of the ice sheets of Greenland and Antarctica.

**Objective**

After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

**Content**

The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

### Lecture notes

Will be provided on Moodle

### Literature

A list of relevant literature is available on Moodle

### Prerequisites / notice

High-school mathematics and physics knowledge required.

### 701-1631-00L Foundations of Ecosystem Management

**Abstract**

This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

**Objective**

Students should be able to

a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.

b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

**Content**

Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

### Lecture notes

No Script

### Literature


### 701-0535-00L Environmental Soil Physics/Vadose Zone Hydrology

**Abstract**

The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

**Objective**

Students are able to

- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils

### Literature


### Notice

Waiting list will be deleted on 30.09.2022

### Target groups

Priority is given to the target groups until 26.09.2022,

Target groups

- MAS ETH in Raumplanung
- MAS ETH in Sustainable Water Resources
- Science, Technology and Policy MSc
- Environmental Sciences MSc
- Agricultural Sciences MSc

### Waiting list

Waiting list will be deleted on 30.09.2022

### Autumn Semester 2022

**Course ID**: 701-0535-00L

**Credit Points**: 3 credits

**Target groups**: Agricultural Sciences MSc, Environmental Sciences MSc, Science, Technology and Policy MSc, MAS ETH in Raumplanung

**Description**

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

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Content

Week 1 (September 21): Introduction, content, structure of the course, objectives, bibliography, grading and evaluation; soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density.

Week 2 (September 28): Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation; surface tension; Young-Laplace equation; capillary rise; contact angle.

Week 3 (October 05): Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (including report)

Week 4 (October 12): Soil water content; soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point.

Week 5 (October 19): Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; Demo lab (including report)

Week 6 (October 26): Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman); effective conductivity; unsaturated hydraulic conductivity; Buckingham law.

Week 7 (November 02): Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8 (November 09): Numerical solution of Richards equation – Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)

Week 9 (November 16): Solute and gas transport in soils - Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 9 (November 23): Conductivity and resistance of soils – differences and similarities of hydraulic, electrical, thermal conductivities; Buckingham-Darcy, Fourier, and Archie's law; pore scale characteristics and effective conductivities; soil thermal properties; steady state and non-steady heat flow

Week 11 (November 30): Energy balance and land atmosphere interactions - Radiation and energy balance; evapotranspiration, potential and actual evaporation, definitions and estimation; evaporation stages and characteristic length

Week 12 (December 07): Root water uptake and transpiration – Mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance

Week 13 (December 14): Summary, questions, old exam

Week 14 (December 21): Written Semester-end exam

Literature

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

401-0649-00L  Applied Statistical Regression  W  5 credits  2V+1U  M. Dettling

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies. The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
At the end of the course, students:

- Students will have a broad understanding of the hydrological, biogeochemical, and geomorphological functioning of mountain catchments.
- The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to sustainability assessment.
- Streams are integrated monitors of the health and functioning of their surrounding landscapes. Streams integrate the fluxes of water, solutes, and sediment from the contributing catchment area; thus they reflect the spatially integrated hydrological, biogeochemical, and geomorphological functioning of mountain catchments.
- They will practice using data and models to frame and test hypotheses about connections between streams and landscapes.
- Using a combination of lectures, field exercises, and data analysis, we explore the processes controlling the delivery of water, solutes, and sediment to streams, and how those processes are affected by changes in land cover, land use, and climate. We review the connections between process understanding and predictive modeling in these complex environmental systems.
- Streams are integrated monitors of the health and functioning of their surrounding landscapes. Streams integrate the fluxes of water, solutes, and sediment from the contributing catchment area; thus they reflect the spatially integrated hydrological, ecophysiological, biogeochemical, and geomorphological processes in the surrounding landscape. At a practical level, there is a significant public interest in managing forested upland landscapes to provide a reliable supply of high-quality surface water and to minimize the risk of catastrophic flooding and debris flows, but the scientific background for such management advice is still evolving.

### Books

- **Mountain Forest Hydrology**
  - J. W. Kirchner
  - This course presents a process-based view of the hydrology, biogeochemistry, and geomorphology of mountain streams. Students learn how to integrate process knowledge, data, and models to understand how landscapes regulate the fluxes of water, sediment, nutrients, and pollutants in streams, and to anticipate how streams will respond to changes in land use, atmospheric deposition, and climate.

- **Land-Climate Dynamics**
  - S. I. Seneviratne, R. Padrón Flasher, P. Sieber
  - The target groups are the following:
    - PHD student Environmental sciences
    - MSc in Atmospheric and climate science
    - MSc in Environmental sciences

### Literature

- Handouts are provided.
- Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L).

### Prerequisites / notice

- Number of participants limited to 36.
- Priority is given to the target groups until 19.09.2022.
- The target groups are the following:
  - PhD student Environmental sciences
  - MSc in Atmospheric and climate science
  - MSc in Environmental sciences

### Registration

- Registration for the course is possible until 30.09.2022.
- Waiting list will be deleted at the same date.

### Notes

- Handouts will be available as they are developed.

### Content

- The course is structured as follows:
  - overview of rationale, objectives, concepts and origins of sustainable development (approx. 15%)
  - overview of the concept of social justice as guiding principle of the social dimension of sustainability (approx. 20%)
  - analysis of a selection of concepts and methodologies to assess sustainable development in a variety of contexts (approx. 65%)

### Prerequisites

- The course is for students in the following programs:
  - MSc in Environmental sciences
  - MSc in Atmospheric and climate science
  - PhD student Environmental sciences
- The target groups are the following:
  - PhD student Environmental sciences
  - MSc in Atmospheric and climate science
  - MSc in Environmental sciences

### Competencies

- Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L).

### Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

### Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

### Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Literature

- Selected scientific articles and book-chapters

### Lecture notes

- Handouts will be available as they are developed.

### Waiting list

- Waiting list will be deleted at the same date.
Abstract
The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

Objective
The students can understand the role of land processes and associated feedbacks in the climate system.

Lecture notes
Powerpoint slides will be made available

Prerequisites / notice
Prerequisites: Introductory lectures in atmospheric and climate science

401-6217-00L
Using R for Data Analysis and Graphics (Part II)
W 1.5 credits 1G M. Mächler

Abstract
The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical functions, important statistical functions, types of objects, models, programming and writing functions.

Objective
The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

Content
Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options;
- Extending basic R: packages

Lecture notes
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

Prerequisites / notice
Basic knowledge of R equivalent to "Using R .. (part 1)" (= 401-6215-00L ) is a prerequisite for this course.

The course resources will be provided via the Moodle web learning platform. As from FS 2019, subscribing via Mystudies should *automatically* make you a student participant of the Moodle course of this lecture, which is at

https://moodle-app2.let.ethz.ch/course/view.php?id=15522

Master's Thesis

Number Title Type ECTS Hours Lecturers
118-0121-00L Master's Thesis O 24 credits 51D Lecturers

Abstract
Students propose relevant research topics from their home countries or from ongoing research projects at ETH, around which individual study programmes are devised, and on which they write their thesis. The Master thesis is supervised by scientific staff at ETH and collaborating institutions, and is based on the student's academic or professional experience.

Objective
The Master Thesis research takes place throughout the duration of the MAS Programme (12 months), complimented by Master level coursework and seminars focusing on water resources and sustainability. Students become familiar with new research techniques and receive guidance from experts. The topic of the research should address a current water resources challenge in the student's home country or in Switzerland, and is aimed at enhancing collaboration between academics and professionals in Switzerland and abroad.

MAS in Sustainable Water Resources - Key for Type

O Compulsory
W+ Eligible for credits and recommended
W Eligible for credits

E- Recommended, not eligible for credits
Z Courses outside the curriculum
Dr Suitable for doctorate

Key for Hours

V lecture
G lecture with exercise
U exercise
S seminar
K colloquium

P practical/laboratory course
A independent project
D diploma thesis
R revision course / private study

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Technology and Public Policy

Two-semester full-time or four-semester part-time programme.

More information at: https://tpp.ethz.ch/tpp-degrees/mas-tpp.html

▶ Compulsory Modules

▶▶ Policy Process

The Modules take place only in Spring Semester.

▶▶ Impact Analysis

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td></td>
<td>Only for CAS in Technology and Public Policy: Impact</td>
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<tr>
<td></td>
<td>Analysis and MAS in Technology and Public Policy</td>
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<tr>
<td>Abstract</td>
<td>Markets play an important function in modern societies by allocating resources and capital. Yet, important market failures require the intervention of public policy. This module introduces the fundamentals of micro- and macro-economics and thereby lays the foundation for the economic assessment of policy interventions.</td>
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<tr>
<td>Objective</td>
<td>How Markets Function (Microeconomics): Participants (1) understand basic principles, problems and approaches in microeconomics, (2) can analyse and explain simple economic principles in a market using supply and demand graphs, (3) can contrast different market structures and describe firm and consumer behaviour, (4) can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole, (5) can address utility maximization and cost minimization problems. How Economic Systems Function (Macroeconomics): Participants understand (1) the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates, (2) how inflation and real economic activity fluctuates, (3) what economic policy can do against unemployment and inflation, (4) what significance international economic relations have for specific countries, such as Switzerland.</td>
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<tr>
<td>Literature</td>
<td>Course materials can be found on Moodle.</td>
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<thead>
<tr>
<th>876-0201-00L</th>
<th>Technology and Policy Analysis</th>
<th>O</th>
<th>8</th>
<th>5G</th>
<th>T. Schmidt, E. Ash, F. M. Egli,</th>
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<tbody>
<tr>
<td></td>
<td>Only for CAS in Technology and Public Policy: Impact</td>
<td></td>
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<td>R. Garrett, M. Leese, A. Rom,</td>
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<tr>
<td></td>
<td>Analysis and MAS in Technology and Public Policy</td>
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<td></td>
<td>B. Steffen</td>
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<tr>
<td>Abstract</td>
<td>Technologies substantially affect the way we live and how our societies function. Technological change, i.e. the innovation and diffusion of new technologies, is a fundamental driver of economic growth but can also have detrimental side effects. This module introduces methods to assess technology-related policy alternatives and to analyse how policies affect technological changes and society.</td>
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<tr>
<td>Objective</td>
<td>Introduction: Participants understand (1) what ex ante and ex post policy impact analysis is, (2) in what forms and with what methods they can be undertaken, (3) why they are important for evidence- based policy- making. Analysis of Policy and Technology Options: Participants understand (1) how to perform policy analyses related to technology; (2) a policy problem and the rationale for policy intervention; (3) how to select appropriate impact categories and methods to address a policy problem through policy analysis; (4) how to assess policy alternatives, using various ex ante policy analysis methods; (5) and how to communicate the results of the analysis. Evaluation of Policy Outcomes: Participants understand (1) when and why policy outcomes can be evaluated based on observational or experimental methods, (2) basic methods for evaluating policy outcomes (e.g. causal inference methods and field experiments), (3) how to apply concepts and methods of policy outcome evaluation to specific cases of interest. Big Data Approaches to Policy Analysis: Participants understand (1) why &quot;big data&quot; techniques for making policy- relevant assessments and predictions are useful, and under what conditions, (2) key techniques in this area, such as procuring big datasets; pre- processing and dimension reduction of massive datasets for tractable computation; machine learning for predicting outcomes; interpreting machine learning model predictions to understand what is going on inside the black box; data visualization including interactive web apps.</td>
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<tr>
<td>Literature</td>
<td>Course materials can be found on Moodle.</td>
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<tr>
<th>876-0301-00L</th>
<th>Policy-Making in Practice</th>
<th>O</th>
<th>4</th>
<th>3G</th>
<th>T. Bernauer, D. N. Bresch,</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td></td>
<td>Analysis and MAS in Technology and Public Policy</td>
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<tr>
<td>Abstract</td>
<td>Effective management of risks and uncertainty as well as communication of scientific evidence to stakeholders and policy-makers are essential for successful policy-advice and policy-making. Hence, this module conveys the fundamentals of risk analysis/management and of writing for policy-makers. Besides an academic perspective, it features practitioners working at the technology-policy interface.</td>
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<tr>
<td>Objective</td>
<td>Risk Analysis and Risk Management: Participants understand (1) the role risk and uncertainty play in decision- and policy- making, (2) common approaches to risk management, (3) how to apply methods of quantitative risk analysis, (4) how to communicate risk information clearly and effectively. Writing for Policy-Makers: Participants understand (1) particular prerequisites for successful dissemination of scientific results to policy- makers and the wider public, (2) expectations and needs of different target groups and audiences, (3) how to effectively write policy briefs for stakeholders and policy-makers.</td>
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<tr>
<td>Literature</td>
<td>Course materials can be found on Moodle.</td>
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▶ Electives

MAS students can choose from the Science in Perspective course offer or related courses. Enrollment only after agreement with the TPP Programme Leadership.

▶ Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<td>877-0400-00L</td>
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<td>O</td>
<td>15</td>
<td>32D</td>
<td>Lecturers</td>
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<td>Only for MAS in Technology and Public Policy.</td>
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<td></td>
<td>Enrollment only after agreement with the TPP Programme Leadership.</td>
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<tr>
<td>Abstract</td>
<td>The MAS students focus on a specific policy problem and carry out a policy analysis either within an ETH research group or with a project partner from the public, private or civic sector. In either case, the policy analysis project requires an ETH professor as supervisor, who is also responsible for grading the thesis.</td>
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<tr>
<td>Objective</td>
<td>Apply the policy analysis skills acquired throughout the MAS TPP programme.</td>
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</table>
### MAS in Technology and Public Policy - Key for Type

<table>
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<tr>
<th>Code</th>
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<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
<thead>
<tr>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
MAS in Urban and Territorial Design
The MAS in Urban and Territorial Design requires one year of full-time postgraduate study for a 60 ECTS joint degree, the "MAS ETH EPF UTD". It is taught in English and held at the two Swiss schools, EPFL (Autumn) and ETH Zurich (Spring).

### Design Studio and Postproduction

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>078-0100-00L</td>
<td>Core Design and Research Studio I (EPFL)</td>
<td>Only</td>
<td>16</td>
<td>17G</td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td>MAS ETH EPF UTD</td>
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<td></td>
<td>Lecturers: P. Viganò with C. Fivet, L. Rossi and guests. The Core Studio will reflect on the “transition”, assuming its multiple dimensions (ecological, social and economic) and developing transcalar design operations in concrete territories. The territory of Greater Geneva will be the test-bed for radical design explorations of possible futures.</td>
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<td><strong>Objective</strong></td>
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<td>Different urban conditions will be considered in order to understand, read and manage the thick complexity of the contemporary habitat where densities, distances, relations and practices shape heterogeneous spaces and ecologies. Conceived as a place of interaction among disciplines, the studio also constitutes the main tool to develop interdisciplinarity within the design practice.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>A series of lectures will deal with ecology; the organism and its environment; population and community ecology; and biodiversity. Others lectures on design as knowledge production and on representation—GIS, video and photography—will be embedded within the activities of the studio. Fieldwork is integral to the design studio.</td>
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<tr>
<td>078-0101-00L</td>
<td>Postproduction I (EPFL)</td>
<td>Only</td>
<td>2</td>
<td>2G</td>
<td>external organisers</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td>MAS ETH EPF UTD</td>
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<td></td>
<td>Lecturer: P. Viganò. The last period of the semester in January will consist of a post-production session, related to the results at EPFL. It mainly concerns the products of the Core Studio, but will also be implemented by the associated teaching.</td>
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<td><strong>Objective</strong></td>
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<td>All research and design materials produced during the studio, courses and sessions (e.g. texts, maps, drawings, etc.) will be evaluated, edited and curated in a “Semester Report” by the core teaching team and a graphic designer. At the end, the &quot;Report&quot; will be available online.</td>
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### Interdisciplinary Courses

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<tr>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>078-0200-00L</td>
<td>City, Habitat and Mobility (EPFL)</td>
<td>Only</td>
<td>3</td>
<td>3G</td>
<td>external organisers</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td>MAS ETH EPF UTD</td>
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<td></td>
<td>Lecturers: V. Kaufmann with L. Pattaroni. The course aims to understand the political and social conditions of urban lifestyles and mobilities patterns in order to explore the levers of action available to professionals to support the critical emergence of renewed urban models.</td>
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<td><strong>Objective</strong></td>
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<td>Taking the form of a course - seminar, the proposed teaching aims to show the interest of methodologies from the social sciences of the city to develop critical urban and territorial design. Planned to last 12 weeks, it proposes to take up each week a theme related to the relation between city, habitat and mobility.</td>
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<td>Each session is organized in two parts: (1) a presentation by one of the students of an article on the week’s theme, followed by a discussion, and (2) a presentation by the teaching team to identify the knowledge and debates of social sciences related to urban and territorial design issues. Two sessions will be devoted to field visits.</td>
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<tr>
<td>078-0201-00L</td>
<td>Building Design in the Circular Economy (EPFL)</td>
<td>Only</td>
<td>3</td>
<td>3G</td>
<td>external organisers</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td>MAS ETH EPF UTD</td>
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<td>Lecturer: C. Fivet. The circular economy consists in maintaining the value of products as long as possible by extending or renewing their service life while minimizing resource depletion, waste and greenhouse gas emissions. The integration of these principles in the construction industry has many facets that often contradict each other.</td>
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<td><strong>Objective</strong></td>
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<td>While introducing students to the concept of the circular economy and its applications to building design, the class provides ready-to-use techniques and aims at developing a critical mindset towards their use. Following a 'flipped classroom' methodology, the class devles into recent literature and practice by means of adversarial open debates. Examination consists in the writing of a short personal essay on a chosen topic and its oral defence.</td>
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<tr>
<td>078-0202-00L</td>
<td>Urban Hydrology (EPFL)</td>
<td>Only</td>
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<td>2G</td>
<td>external organisers</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td>MAS ETH EPF UTD</td>
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<td>Lecturer: L. Rossi. This course addresses water management from a global point of view, including in particular the impacts of rain discharges on receiving environments. The qualitative aspects (risk of contamination) are considered as a priority, in parallel with the quantitative risks (floods).</td>
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<td><strong>Objective</strong></td>
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<td>The course aims to understand the means and issues of management and maintenance of sewerage systems, finalized to the control of impacts in receiving environments, and more generally to raise the importance of hydraulic management in the urban and territorial project.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>General introduction - Legislative aspects related to urban hydrology - Simplified design methods and technical solutions: from source control to solutions at the end of the network - Field visits</td>
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<tr>
<td>052-0733-22L</td>
<td>Introduction to the Fundamentals of Natural Environment</td>
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<td>1</td>
<td>2V</td>
<td>T. Gali-Izard</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td>MAS ETH EPF UTD</td>
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<td>This course is suitable for MSc and MAS UTD students only! Only few places left! As of 13.9.22, please contact the chair <a href="mailto:converso@arch.ethz.ch">converso@arch.ethz.ch</a>.</td>
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<td><strong>Objective</strong></td>
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<td>Participants become acquainted with relevant issues and topics about the natural environment and gain valuable insights into the interaction of all living and non-living things, climate, weather and natural resources. The active participation in discussions following presentations by invited lecturers stimulate critical thinking and allow participants to tackle relevant environmental challenges and discuss opportunities with academics and experts as well as to exchange ideas amongst the participants.</td>
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</table>
This course is a series of lectures by academics and experts who present their research and fundamental knowledge across the field of the environmental sciences (geology, climate, ecology, soil and plant sciences). The active participation in critical discussions following each presentation allows participants to tackle relevant challenges in the natural environment with academics and experts.

Tuesday 20.9.22, 9-11:30: «Land-Climate Dynamics» with Dr. Jonas Schwaab, Dr. Gianluca Mussetti
Thursday 22.9.22 9-11:30: «Introduction to Geology» with Dr. Maria Giuditta Fellin, Dr. Vincenzo Picotti - Gebäude NO D1 (Sonnewegstraasse 5 “Focus Terra”)
Monday 10.10.22; 9-11:30: «Soil Biology & Ecology» with Dr. Aline Frossard
Thursday 13.10.22, 9-11:30: «Tree Architecture & Evolution» with Dr. Guillaume Chemicki
Friday 14.10.22, 9-11:30: «Plant Systematics I» with Alessia Dr. Guggisberg
Friday 21.10.22, 9-11:30: «Disturbance Ecology» with Dr. Thomas Wohlgemuth

More details about each lectures, as well as keywords and topics relevant for and discussed during the lectures are published in advance on the course web page: mscla.arch.ethz.ch

The lectures are going to be live-streamed on Zoom: https://ethz.zoom.us/j/69300707903

No previous knowledge in environmental sciences is required.

### Urban Theory Sessions

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>078-0300-00L</td>
<td>Histories of Environment (EPFL)</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturers: S. Marot and guests. As a guiding principle that remains to be defined, the transition can be critically confronted with broader histories of the environment. The various and even very opposite hypotheses it contains will be differentiated and deepened in the module. In particular that of autonomy will be discuss regarding to the so-called &quot;secession&quot; scenario.</td>
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</tr>
<tr>
<td>Objective</td>
<td>This session aims to understand how and to what extent environmental concerns can influence urban and territorial design. From a critical point of view, it also intends to question the notion of transition under the prism of its antecedents in ecological thinking.</td>
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</tr>
<tr>
<td>078-0301-00L</td>
<td>Systemic Thinking in the Age of Transition (EPFL)</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td>Only for MAS in Urban and Territorial Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Lecturers: E. Cogato-Lanza, A. Pagani, guests. Systems thinking has regained its topicality due to the need to apprehend interdependencies that characterize our inhabited environment. The technicist approach, which had favored complexity without relating it to systems, has given way to interdisciplinary, contextual and holistic frameworks of understanding and action that lead to new prototypes.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The seminar intends to draw up a cartography of the most current theoretical references and strategic experiments of systemic thinking in the field of the territorial project. The two envisaged formats will associate the series of conferences, bringing together protagonists and researchers, with more strictly seminal sessions with a comparative, inventory or bibliographical tone.</td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>The seminar is structured in four modules: Polemics; Concepts; Representations; Projects.</td>
<td></td>
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</tr>
</tbody>
</table>

### MAS in Urban and Territorial Design - Key for Type

<table>
<thead>
<tr>
<th>Key for Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### MAS Mediation in Peace Processes

#### Modules

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>868-0001-00L</td>
<td>Module 1: Mediation in Context</td>
<td>O</td>
<td>10</td>
<td>9G</td>
<td>A. Wenger, L.-E. Cederman</td>
</tr>
<tr>
<td></td>
<td><em>Does not take place this semester.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Only for MAS Mediation in Peace Processes.</em></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This module defines and contextualises peace mediation in relation to other conflict resolution approaches. The module focuses heavily on conflict analysis, introducing the students to the latest knowledge about conflict typologies, trends, and causes in addition to providing them with various opportunities to practice conflict analysis using diverse methods.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>This module defines and contextualises peace mediation in relation to other conflict resolution approaches. The module focuses heavily on conflict analysis, introducing the students to the latest knowledge about conflict typologies, trends, and causes in addition to providing them with various opportunities to practice conflict analysis using diverse methods.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>868-0004-00L</td>
<td>Module 4: Mediation Process Design</td>
<td>O</td>
<td>10</td>
<td>9G</td>
<td>A. Wenger</td>
</tr>
<tr>
<td></td>
<td><em>Only for MAS Mediation in Peace Processes.</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Mediators help the parties reach a peace agreement by designing and structuring the process. This module covers the basic elements of process design and how they differ. Important to process design is the reflection on theory and practice in sequencing the content to be examined. The module then explores the implications and challenges facing the implementation of peace agreements for mediators.</td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Mediators help the parties reach a peace agreement by designing and structuring the process. This module covers the basic elements of process design and how they differ. Important to process design is the reflection on theory and practice in sequencing the content to be examined. The module then explores the implications and challenges facing the implementation of peace agreements for mediators.</td>
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#### MAS Mediation in Peace Processes - Key for Type

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>Lecture</th>
<th>Lecture with Exercise</th>
<th>Exercise</th>
<th>Seminar</th>
<th>Colloquium</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Key for Hours

- **V**: lecture
- **G**: lecture with exercise
- **U**: exercise
- **S**: seminar
- **K**: colloquium
- **P**: practical/laboratory course
- **A**: independent project
- **D**: diploma thesis
- **R**: revision course / private study

#### ECTS

- European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Primary educational objective is to learn programming with C++. When successfully attended the course, students have a good command.

Mechanics I
Lecturers
Linear Algebra I
2V+2U
Übungsblätter

2V+2U
A. Steiger

Upon completion of this course, students will be able to recognize linear structures, and to solve corresponding problems in theory and in practice. The new notions are practised in the accompanying exercise classes. The course will be continued as Linear algebra II.

3V+2U+1K
151-0501-03L
Mechanics I

Basics: Position of a material point, velocity, kinematics of rigid bodies, forces, reaction principle, mechanical power
Statics: Groups of forces, moments, equilibrium of rigid bodies, reactions at supports, parallel forces, center of gravity, statics of systems, principle of virtual power, trusses, frames, forces in beams and cables, friction.

Statik: Aequivalenz und Reduktion von Kräftegruppen; Ruhe und Gleichgewicht, Hauptsatz der Statik; Lagerbindungen und Lagerkräfte, Lager bei Balkenträgern und Wellen, Vorgehen zur Ermittlung der Lagerkräfte; Parallele Kräfte und Schwerpunkt; Statik der Systeme, Behandlung mit Hauptsatz, mit Prinzip der virtuellen Leistungen, statisch unbestimmte Systeme; Statisch bestimmte Fachwerke, ideale Fachwerke, Pendelstützungen, Knotengleichgewicht, räumliche Fachwerke; Reibung, Haftreibung, Gleitreibung, Gelenk und Lagerreibung, Rollreibung; Seilstatik; Beanspruchung in Stab trägern, Querkraft, Normalkraft, Biege- und Torsionsmoment

Übungsblätter

Sayir, M.B., Dual J., Kaufmann S., Mazza E., Ingenieurmechanik 1: Grundlagen und Statik, Springer


To provide a thorough understanding of the basic principles of chemistry and its application,
1) To provide a thorough understanding of the basic principles of chemistry and its application,
2) To develop an understanding of the atomic and molecular nature of matter and of the chemical reactions that describe its transformations, and
3) To emphasize areas considered most relevant in an engineering context.

Electronic structure of atoms, chemical bonding, molecular geometry and bonding theories, intermolecular forces, gases, thermodynamics, chemical thermodynamics, chemical kinetics, equilibria, liquids and solutions, acids and bases, redox- and electrochemistry.


Additional First Year Courses
151-0321-00L  Engineering Design and Material Selection  O  4 credits  4G  K. Shea

Abstract
This course provides an introduction to engineering design. Through hands-on, practice-oriented exercises, students experience the fundamentals of design concept generation and selecting materials. They create 3D models in CAD for their own customized design and fabricate them using 3D printing. Three case studies in healthcare, mobility and sustainable materials will be explored.

Objective
The lecture and exercises teach the fundamentals of engineering design, drawing and CAD as well as additive manufacturing and material selection. After taking the course, students will be able to tackle simple design tasks, generate and evaluate concepts, accurately create technical drawings of parts and assemblies as well as read them. Students will also be able to create models of parts and assemblies in a 3D, feature-based CAD system. They will understand the links between engineering design and material selection, with a particular focus on sustainable materials, as well as additive manufacturing.

Content
Introduction to Engineering Design
- design requirements
- concept generation and selection
- prototyping

Design Representations
- Technical Drawing:
  - projections, views and cuts
  - dimensioning
  - assemblies
- CAD:
  - CAD modeling operations
  - parametric design and feature-based modeling
  - assemblies
  - creating 2D drawings from 3D part models

Fabrication and Additive manufacturing
Material Selection
- materials and their properties, with special emphasis on sustainable materials
- basic mechanics
- material selection processes
- testing material properties

Three case studies in healthcare, mobility and sustainable materials

Lecture notes
Lecture slides and exercise handouts are available on the course Moodle website: https://moodle-app2.let.ethz.ch/course/view.php?id=17403

Literature
All literature will be given on the Moodle website: https://moodle-app2.let.ethz.ch/course/view.php?id=17403

Prerequisites / notice
This course is given as a lecture (1h/week) and an exercise (3h/week). Students are split into working groups for the exercises with a maximum of 20 students per group.

Semester Fee
A fee is charged for printed copies of the course handouts and 3D printing.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies assessed
- Problem-solving assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Leadership and Responsibility assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed

Personal Competencies
- Adaptability and Flexibility assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

Bachelor Studies (Programme Regulations 2010)
3. Semester: Compulsory Courses

Examination Block 1

401-0363-10L  Analysis III  O  3 credits  2V+1U  A. Iozzi

Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.
Content

Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Lecture notes

Lecture notes by Prof. Dr. Alessandra Iozzi:
https://polybox.ethz.ch/index.php/s/D3K0TayQXvfpCAA

Literature


For reference/complement of the Analysis I/II courses:

Christian Blatter: Ingenieur-Analysis
https://people.math.ethz.ch/~blatter/dlp.html

151-0503-00L Dynamics 6 credits 4V+2U D. Kochmann

Abstract
Dynamics of particles, rigid bodies and deformable bodies: Motion of a single particle, motion of systems of particles, 2D and 3D motion of rigid bodies, vibrations, waves

Objective
This course provides Bachelor students of mechanical and civil engineering with fundamental knowledge of the kinematics and dynamics of mechanical systems. By studying the motion of a single particle, systems of particles, of rigid bodies and of deformable bodies, we introduce essential concepts such as kinematics, kinetics, work and energy, equations of motion, and forces and torques. Further topics include the stability of equilibria and vibrations as well as an introduction to the dynamics of deformable bodies and waves in elastic rods. Throughout the course, the basic principles and application-oriented examples presented in the lectures and weekly exercise sessions help students acquire a proficient background in engineering dynamics, learn and embrace problem-solving techniques for dynamical engineering problems, gain cross-disciplinary expertise (by linking concepts from, among others, mechanics, mathematics, and physics), and prepare students for advanced courses and work on engineering applications.

Content
1. Motion of a single particle: kinematics (trajectory, velocity, acceleration), forces and torques, constraints, active and reaction forces, balance of linear and angular momentum, work-energy balance, conservative systems, equations of motion.
2. Motion of systems of particles: internal and external forces, balance of linear and angular momentum, work-energy balance, rigid systems of particles, particle collisions, mass accretion/loss.
3. Motion of rigid bodies in 2D and 3D: kinematics (angular velocity, velocity and acceleration transfer, instantaneous center and axis of rotation), balance of linear and angular momentum, work-energy balance, rigid angular momentum transport, inertial vs. moving reference frames, apparent forces, Euler equations.
5. Introduction to waves and vibrations in deformable elastic bodies: local form of linear momentum balance, waves and vibrations in slender elastic rods.

Lecture notes
Lecture notes (a scriptum) will be available on Moodle. Students are strongly encouraged to take their own notes during class.

Literature
A complete set of lecture notes (a scriptum) is available on Moodle. Further reading materials are suggested but not required for this class.

Prerequisites / notice
All course materials (including lecture notes, exercise problems, etc.) are available on Moodle.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

151-0303-00L Dimensioning I

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>The goal of the lecture is to build on and extend the theories from Mechanics 2. Students learn how to implement adequate models for practical dimensioning problems in mechanical engineering and how to solve and critically interpret these models.</td>
<td></td>
</tr>
</tbody>
</table>
- Basic problem of continuum mechanics
- Structural theories
- Introduction to finite element methods
- Strength of materials
- Fatigue
- Stability of structures

Abstract
Introduction to Dimensioning of components and machine parts. Basic structural theories are introduced and a short introduction to finite elements is given. Further, elements from fracture mechanics, plasticity and stability of structures are presented.

Lecture notes
Will be announced during the first lecture.

Literature
Will be announced during the first lecture.

151-0051-00L Thermodynamics I

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to the fundamentals of technical thermodynamics.</td>
<td></td>
</tr>
</tbody>
</table>
1. Konzepte und Definitionen
2. Der erste Hauptsatz, der Begriff der Energie und Anwendungen für geschlossene Systeme
3. Eigenschaften reiner kompressibler Substanzen, quasistatische Zustandsänderungen
4. Elemente der kinetischen Gastheorie
5. Der erste Hauptsatz in offenen Systemen - Energieanalyse in einem Kontrollvolumen
6. Der zweite Hauptsatz - Der Begriff der Entropie
7. Nutzbarkeit der Energie - Exergie
8. Thermodynamische Beziehungen für einfache, kompressible Substanzen.

Abstract
Introduction to the fundamentals of technical thermodynamics.

Content
- Basic problem of continuum mechanics
- Structural theories
- Introduction to finite element methods
- Strength of materials
- Fatigue
- Stability of structures

Lecture notes
available

Literature


151-0591-00L Control Systems I

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the role and importance of control systems in everyday life. Obtain models of single-input single-output (SISO) linear time invariant (LTI) dynamical systems. Linearization of nonlinear models. Interpret stability, observability and controllability of linear systems. Describe and associate building blocks of linear systems in time and frequency domain with equations and graphical representations (Bode plot, Nyquist plot, root locus). Design feedback controllers to meet stability and performance requirements for SISO LTI systems. Explain differences between expected and actual control results. Notions of robustness and other nuisances such as discrete time implementation.</td>
<td></td>
</tr>
</tbody>
</table>

Abstract
Analysis and controller synthesis for linear time invariant systems with one input and one output signal (SISO); transition matrix; stability; controllability; observability; Laplace transform; transfer functions; transient and steady state responses. PID control; dynamic compensators; Nyquist theorem.

Lecture notes
Lecture slides and additional material will be posted online.
There is no required textbook.

A nice introductory book on feedback control, available online for free, is:

Feedback Systems: An Introduction for Scientists and Engineers
Karl J. Astrom and Richard M. Murray

The book can be downloaded at https://fbswiki.org/wiki/index.php/Main_Page

Basic knowledge of (complex) analysis and linear algebra.

**Prerequisites / notice**

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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<td>not assessed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method-specific Competencies</th>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision-making</td>
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<tr>
<td>Media and Digital Technologies</td>
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<tr>
<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<table>
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<tr>
<th>Social Competencies</th>
<th>Communication</th>
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</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
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<td></td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
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<td></td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
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<td></td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Negotiation</td>
<td>not assessed</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
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### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0033-10L</td>
<td>Physics I</td>
<td>O</td>
<td>6</td>
<td>4V+2U</td>
<td>L. Degiorgi</td>
</tr>
</tbody>
</table>

**Abstract**

This is a one-semester course introducing students into the foundations of Modern Physics. Topics include electricity and magnetism, light, oscillations and waves with Doppler effect. Selected topics with important applications in industry will also be considered.

**Objective**

The lecture is intended to promote critical, scientific thinking. Key concepts of Physics will be acquired, with a focus on technically relevant applications. At the end of the semester, students will have a good overview over the topics of classical and modern Physics.

**Content**

Electric and magnetic fields, current, magnetism, Maxwell's equations, oscillations, waves.

**Lecture notes**

Notes from lectures will be available (in German).

**Literature**

Hans J. Paus, Physik in Experimenten und Beispielen, Carl Hanser Verlag München Wien (textbook for the lecture), ca. 50 Euro.

alternative E-Book:


### 3. Semester: Engineering Tools

The Engineering Tools courses are for MAVT Bachelor's degree students only.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0021-00L</td>
<td>Engineering Tool: Introduction to MATLAB</td>
<td>W+</td>
<td>0.4</td>
<td>1K</td>
<td>B. Berisha</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to MATLAB; vectors and matrices; graphics in MATLAB; calculus, differential equations; programming with MATLAB; data analysis and statistics; interpolation and polynomials. Excercises with solutions: using MATLAB commands, technical applications.

**Objective**

Introduction to numerical calculations with MATLAB.

**Content**

Introduction to MATLAB; vectors and matrices; graphics in MATLAB; calculus, differential equations; programming with MATLAB; data analysis and statistics; interpolation and polynomials. Excercises with solutions: using MATLAB commands, technical applications.

**Lecture notes**

Course material: https://moodle-app2.let.ethz.ch/course/view.php?id=15113
**Objectives**

- Understand and apply thermodynamic principles and processes for use in a range of cycles used commonly in practice.

**Abstract**

Understand and apply thermodynamic principles and processes for use in a range of cycles used commonly in practice.

**Content**

- Undergraduate thermodynamics
- Ideal and real gases
- Thermodynamic cycles
- Compressibility
- Heat exchangers
- Refrigeration systems
- Thermoelectricity
- Psychrometry
- Steam processes
- Gas turbine processes
- Internal combustion engines
- Steam power plants
- Process engineering

**ECTS**

2 credits

**Lecturers**

F. O. Friedrich Wicker

**Prerequisites / notice**

Course can only be taken if the programming project is executed and submitted. If no solution to the programming project is submitted, the course is considered failed («no show»).

**5. Semester: Compulsory Courses Examination Block 3**

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
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<td>Thermodynamics III</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>R. S. Abhari, A. Steinfeld</td>
</tr>
<tr>
<td>151-0103-00L</td>
<td>Fluid Dynamics II</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Jenny</td>
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<tr>
<td>151-0573-00L</td>
<td>System Modeling</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>L. Guzzella</td>
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**Electives**

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<thead>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>121-0573-00L</td>
<td>Microprocessors</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>L. Guzzella</td>
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</table>

**Data: 01.11.2022 12:41**

Autumn Semester 2022

Page 1571 of 2416


Not assessed


4 credits

Lightweight design

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic

Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the

Lecture notes available on course website.

assessed

2V+2U

F. Donat

The goal of this course is to convey substantiated background for the understanding and the design and sizing of modern lightweight

The elective course Lightweight includes numerical methods for the analysis of the load carrying and failure behavior of lightweight

Not assessed

Lecture notes available on course website.

Not assessed

Not assessed

Prerequisites / notice

Control Systems I is helpful but not required.

Lecture notes

A script is provided (German language).

Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the

Lecture notes

Script, Handouts, Exercises

Mass Transfer

Objective

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic

Content

Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's

Mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories;

simultaneous heat, mass and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible

communications; mass transfer and first order heterogeneous reaction. Applications.

Literature


Prerequisites / notice

Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0975-01L

Signals and Systems

W 4 credits 2V+2U A. Carron

Abstract

Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

Objective

Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

Content


Literature

Prerequisites / notice

Control Systems I is helpful but not required.

151-0917-00L

Mass Transfer

W 4 credits 2V+2U S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Abstract

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content

Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature

Prerequisites / notice

Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0973-00L

Introduction to Process Engineering

W 4 credits 2V+2U F. Donat, C. Müller

Abstract

Overview of process engineering: fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

Objective

We teach the fundamentals of process engineering using practical examples as well as concrete process engineering problems in the areas of process control and balancing, thermal separation processes, mechanical separation processes and reaction engineering.

Content

Overview of process engineering: fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

In addition to teaching basic theoretical knowledge, the focus is on solving typical problems in various subdisciplines of process engineering.

Literature

Prerequisites / notice

A script is provided (German language).

Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the lecture and the exercise materials are sufficient.

151-3207-00L

Lightweight

W 4 credits 2V+2U P. Ermanni, T. Tancogne-Dejean, M. Zogg

Abstract

The elective course Lightweight includes numerical methods for the analysis of the load carrying and failure behavior of lightweight structures, as well as construction methods and design principles for lightweight design.

Objective

The goal of this course is to convey substantiated background for the understanding and the design and sizing of modern lightweight structures in mechanical engineering, vehicle and airplane design.

Content

Lightweight design

Thin-walled beams and structures

Instability behavior of thin walled structures

Reinforced shell structures

Load introduction in lightweight structures

Joining technology

Sandwich design

Literature

Prerequisites / notice

Script, Handouts, Exercises

151-0973-00L

Introduction to Process Engineering

W 4 credits 2V+2U F. Donat, C. Müller

Abstract

Overview of process engineering: fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

Objective

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Literature

Prerequisites / notice

A script is provided (German language).

Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the lecture and the exercise materials are sufficient.

151-3207-00L

Lightweight

W 4 credits 2V+2U P. Ermanni, T. Tancogne-Dejean, M. Zogg

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Reinforced shell structures

Load introduction in lightweight structures

Joining technology

Sandwich design

Literature

Prerequisites / notice

Script, Handouts, Exercises

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1572 of 2416
**Objective**

The following concepts are covered: probabilities, random variables, probability distributions, joint and conditional probabilities and distributions, law of large numbers, central limit theorem, descriptive statistics, statistical inference, parameter estimation, confidence intervals, statistical tests, two-sample tests, linear regression.

**Content**

- Introduction to probability theory and statistics.

**Lecture notes**


**Literature**


Print this page.
Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
The various objectives of the Focus Project are:
- Synthesizing and deepening the theoretical knowledge from the basic courses of the 1.- 4. semester
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

151-0073-20L
SURF-eDNA

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
- Basis examination successfully passed
- Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Content
SURF-eDNA integrates an environmental DNA (eDNA) filter, camera, and swimming autonomy into a biomimetic soft underwater robotic fish (SURF). The goal of the project is to create a biomimetic underwater system capable of the autonomous collection of information about biodiversity in aquatic ecosystems. The system has to be minimally invasive and disruptive to the ecosystem it will be deployed in, therefore it has to employ a nature-mimicking locomotion modality.

The project is run by a team of eight students in their third year of bachelor at MAVT/ITET at ETH Zürich. The team is managed by team from the Soft Robotics Lab. The target date for a successful research demonstration is end of May 2023. The project is split into three work packages: 1) design a robotic fish for underwater sampling; 2) manufacture several robotic prototypes; and 3) provide the system with Autonomy and data collection capability.

If you like to learn more about this project, please email Prof. Robert Katzschmann (rkk@ethz.ch).

Prerequisites / notice
Basics of control theory, machine design, and dynamics. Previous exposure to mechatronics or robotic systems will also be helpful.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
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<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

Social Competencies

| Communication | assessed |
| Cooperation and Teamwork | assessed |
| Customer Orientation | assessed |
| Leadership and Responsibility | assessed |

Personal Competencies

| Adaptability and Flexibility | assessed |
| Creative Thinking | assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | assessed |
| Self-direction and Self-management | assessed |

151-0073-30L
AirX

Does not take place this semester.
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
- Basis examination successfully passed
- Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1574 of 2416
Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
The various objectives of the Focus Project are:
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

Prerequisites / notice
This Focus-Project is supervised by the following lecturers:
Siegwart, R., ASL
Haas, R., ASL
Beardsley P., Disney Research Zurich

151-0073-40L  Magnetic Monkey
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.
Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Abstract
Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective
The various objectives of the Focus Project are:
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

151-0073-50L  MetaSuit
This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.
Prerequisites for the focus projects:
a. Basis examination successfully passed
b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.

Abstract
Students develop soft artificial muscles and integrate these into a full-body suit for immersive experiences. The suit maps the pose and movement of the human body into virtual or augmented reality. The students learn to work in teams, structure problems, identify solutions, perform system analysis, and present. They have access to rapid prototyping facilities and the latest engineering tools.

Objective
The various objectives of the Focus Project are:
- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)
In this focus project, students will develop the platform MetaSuit. Together with their team, they design, build, and test a wearable suit that maps the pose and movement of the human body into a virtual reality (VR) or augmented reality (AR) space. MetaSuit envisions the integration of soft artificial muscles into a full-body suit for immersive experiences. As core enabling technology will serve hydraulically amplified electrostatic actuators that are used both for proprioception and actuation in this project.

This technology fuses thin dielectric films together to deformable pouches, injects the formed pouches with dielectric oil, and coats them with flexible electrodes. Applying low currents at high voltages actuates these capacitors by having the electrodes zip together and pushing the liquid into a sub-portion of the deformable pouch. The key idea here is to read out the zipped state of these capacitive-type actuators and therefore make them sensors.

The project’s main objective is to create a soft, light, and natural feeling suit that allows users to immerse into a target environment where the user can smoothly move and interact with objects and other users. Such target environments can range from dangerous environments that have to be cleaned up to virtual meeting places that enable learning and training.

The project is led by a team of eight undergraduate researchers that are in their 3rd year of bachelor studies at ETH Zurich. Team members have a background in computer science and mechanical/electrical engineering. The supervision and management of the team is provided by the Soft Robotics Lab. The target date for a successful research demonstration is end of May 2023.

If you like to learn more about this project, please email Prof. Robert Katzschmann (rkk@ethz.ch).

Prerequisites / notice
Basics of control theory, machine design, and dynamics. Previous exposure to mechatronics or robotic systems will also be helpful.

Fostered competencies

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<td>Project Management</td>
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<td>Personal Competencies</td>
<td>Self-presentation and Social Influence</td>
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<td>Critical Thinking</td>
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Focus Projects in Manufacturing Science

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<td>e-Sling Hydrogen Powetrain</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>K. Wegener</td>
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<tr>
<td></td>
<td>This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. For MAVT BSc and ITET BSc only. Prerequisites for the focus projects: a. Basis examination successfully passed b. Block 1 and 2 successfully passed For enrollment, please contact the D-MAVT Student Administration. Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc). The various objectives of the Focus Project are: - Synthesizing and deepening the theoretical knowledge from the basic courses of the 1. - 4. semester - Team organization, work in teams, increase of interpersonal skills - Independence, initiative, independent learning of new topic contents - Problem structuring, solution identification in indistinct problem definitions, searches of information - System description and simulation - Presentation methods, writing of a document - Ability to make decisions, implementation skills - Workshop and industrial contacts - Learning and recess of special knowledge - Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)</td>
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</table>

| 151-0075-20L | Formula Student Electric | W    | 0    | 15A   | D. Mohr      |
|              | This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. For MAVT BSc and ITET BSc only. Prerequisites for the focus projects: a. Basis examination successfully passed b. Block 1 and 2 successfully passed For enrollment, please contact the D-MAVT Student Administration. |
Abstract

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Objective

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Focus Projects in Energy, Flows and Processes

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<td>151-0075-30L</td>
<td>eXact - Intelligent Full Electric Excavator</td>
<td>W</td>
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<td>A. Kunz</td>
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</table>

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For MAVT BSc and ITET BSc only.

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For enrollment, please contact the D-MAVT Student Administration.

Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

Objective

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Focus Projects in Energy, Flows and Processes

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<tr>
<td>151-0076-10L</td>
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<td>W</td>
<td>0</td>
<td>15</td>
<td>P. Jenny</td>
</tr>
</tbody>
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For enrollment, please contact the D-MAVT Student Administration.

Abstract

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Focus Projects in Energy, Flows and Processes

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<td>K. Wegener</td>
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b. Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.
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The various objectives of the Focus Project are:
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- Team organization, work in teams, increase of interpersonal skills
- Independence, initiative, independent learning of new topic contents
- Problem structuring, solution identification in indistinct problem definitions, searches of information
- System description and simulation
- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023.

For MAVT BSc and ITET BSc only.

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Prerequisites for the focus projects:
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Focus Projects in Engineering for Health

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-0077-10L</td>
<td>byPulse</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>M. Meboldt</td>
</tr>
<tr>
<td>151-0077-20L</td>
<td>SONANO - Optoacoustic Contrast Agents</td>
<td>W</td>
<td>0</td>
<td>15A</td>
<td>I. Herrmann</td>
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</table>

For MAVT BSc and ITET BSc only.

Prerequisites for the focus projects:
- Basis examination successfully passed
- Block 1 and 2 successfully passed

For enrollment, please contact the D-MAVT Student Administration.
Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

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Focus Projects in Design, Mechanics and Materials

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0079-10L</td>
<td>Multidrone ▶ Does not take place this semester. This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. For MAVT BSc and ITET BSc only.</td>
<td>W</td>
<td>0 credits</td>
<td>15A</td>
<td>P. Ermanni</td>
</tr>
<tr>
<td>151-0079-20L</td>
<td>Retex - Textile Recycling ▶ Does not take place this semester. This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. For MAVT BSc and ITET BSc only.</td>
<td>W</td>
<td>0 credits</td>
<td>15A</td>
<td>P. Ermanni</td>
</tr>
<tr>
<td>151-0079-30L</td>
<td>Swissloop - Scaling to Reality ▶ Does not take place this semester. This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus Project in FS2023. For MAVT BSc and ITET BSc only.</td>
<td>W</td>
<td>0 credits</td>
<td>15A</td>
<td>D. Kochmann</td>
</tr>
</tbody>
</table>
Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

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The various objectives of the Focus Project are:
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- Presentation methods, writing of a document
- Ability to make decisions, implementation skills
- Workshop and industrial contacts
- Learning and recess of special knowledge
- Control of most modern engineering tools (Matlab, Simulink, CAD, CAE, PDM)

151-0079-40L Swissloop Tunneling

Does not take place this semester.

This course is part of a one-year course. The 14 credit points will be issued at the end of FS2023 with new enrolling for the same Focus-Project in FS2023.

For MAVT BSc and IETT BSc only.

Prerequisites for the focus projects:
- a. Basis examination successfully passed
- b. Block 1 and 2 successfully passed

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Abstract

Students develop and build a product from A-Z! They work in teams and independently, learn to structure problems, to identify solutions, system analysis and simulations, as well as presentation and documentation techniques. They build the product with access to a machine shop and state of the art engineering tools (Matlab, Simulink, etc).

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Courses Eligible for Focus Projects

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0079-99L</td>
<td>Vacuum Transport Seminar: Insights into Hyperloop</td>
<td>E</td>
<td>0</td>
<td>1S</td>
<td>D. Kochmann</td>
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<td>Research</td>
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</table>

Abstract

The Vacuum Transport Seminar series enters its third round following the successful editions in spring and autumn semesters. It is held online via Zoom and offered internationally across a number of European Universities. The seminar was founded and is held by Swissloop and the EuroTube Foundation, and partnered by other European institutes.

Objective

Students present their work in Hyperloop research. Additionally, industry experts contribute insight talks. The seminar is open to all students, everyone is welcome to join at any of the dates.

About the seminar’s background:

Swissloop, the Hyperloop Team based at ETH Zürich, is pursuing long-term support for research and education in vacuum transport. In addition to the active team constructing and building a Hyperloop pod every year, various research projects at ETH are pursued in cooperation with EuroTube. The EuroTube Foundation accelerates the development of sustainable vacuum transportation technologies to provide publicly accessible research and testing infrastructures for universities and industry.

About Vacuum Transportation:

The demand for air transport has more than doubled in the last 20 years and is growing yearly by about 6.5%. Global demand for cargo and passenger transportation can barely be met today – let alone in a sustainable manner. Vacuum transport can replace short to medium distance flights and can significantly reduce CO2 emissions. The market of high-speed transportation is a global megatrend set to affect our lives in years to come.

151-0761-00L Practice Course Product Development

Only students for focus projects. 2 up to 3 students per focus project.

Abstract

This course provides comprehensive input to ongoing focus project teams in the areas of project management, communication and presentation, as well as dealing with the media, coaches and patents and safety issues.

Objective

Participants will receive tips, hints and background information from experienced tutors applicable to current projects.
Content

Project Management
- Creating a solid project base
- Project planning and controlling
- Product validation and testing
- Problem solving cycle and decision taking transparent for others

Communication
- Communication within the team and with coaches
- Public Relations in a Nutshell
- How to acquire and manage suppliers and sponsors
- Transfer of technical drawings to suppliers
- Technical reports
- Review presentations

Handling of and guidance to
- Expectation management and dealing with conflicts
- Burnout prevention, time management, work disturbances
- Safety issues
- Issues regarding patents

Prerequisites / notice
- for students only participating in a Focus Project in the same semester
- the exact schedule will be communicated during the course
- it is expected, that every team is visiting each lecture with typically at least 2 team members

Lecture notes
Lecture notes and documentation will be electronically available.

Practice Course to Focus Projects on CAD and CAE Based on Siemens NX
- Max. 3 Students by one Focus Team allowed
- Course is only useful and recommended for students using CAD and CAE Tools for their duty within the project itself
- Feel free to contact us, if there are open questions: martin.schuetz@mavt.ethz.ch

Abstract
This course provides comprehensive input to ongoing Focus Projects teams in the areas of CAD and CAE mit Siemens NX.

Objective
Participants will receive tips, hints and background information from experienced tutors applicable to current projects.

Content
CAD with Siemens NX
- 2 day of intensive training (2x4h, 1x8L)

CAE mit Siemens NX
- 2 separate days of intensive training (2x8L)

Lecture notes
Lecture notes and documentation will be electronically available.

Focus Specialization

Energy, Flows and Processes
Focus Coordinator: Prof. Christoph Müller

In order to achieve the required 20 credit points for the Focus Specialization Energy, Flows and Processes you need to choose at least 2 core courses (W+) (HS/FS) and at least 2 of the elective courses (HS/FS), according to the presentation of the Focus Specialisation (see https://ethz.ch/content/dam/ethz/special-interest/mavt/department-dam/studium/bachelor/documents/EFP_Focus.pdf). One course can be selected among all the courses offered by D-MAVT (Bachelors and Masters).

Number Title Type ECTS Hours Lecturers

Abstract
The course presents an overview of measurement tasks in engineering environments. Different concepts for the acquisition and processing of typical measurement quantities are introduced. Following an initial in-class introduction, laboratory exercises from different application areas (especially in thermofluidics, energy, and process engineering) are attended by students in small groups.

Objective
Introduction to various aspects of measurement techniques, with particular emphasis on thermo-fluidic, energy, and process-engineering applications.
Understanding of various sensing technologies and analysis procedures.
Exposure to typical experiments, diagnostcis hardware, data acquisition, and processing.
Study of applications in the laboratory.
Fundamentals of scientific documentation and reporting.

Content
In-class introduction to representative measurement techniques in the research areas of the participating institutes (fluid dynamics, energy technology, process engineering)
Student participation in 8-10 laboratory experiments (study groups of 3-5 students, dependent on the number of course participants and available experiments)
Lab reports for all attended experiments have to be submitted by the study groups. A final exam evaluates the acquired knowledge individually.

Lecture notes
Presentations, handouts, and instructions are provided for each experiment.

Literature

Prerequisites / notice
- fluid mechanics, thermodynamics, heat and mass transfer
- electrical engineering / electronics
- numerical data analysis and processing (e.g. using MATLAB)

151-0293-00L Combustion and Reactive Processes in Energy and Materials Technology W+ 4 credits 2V+1U+2A N. Noiray, F. Ernst, C. E. Frouzakis
Abstract
This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective
The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content
Reaction kinetics, fuel oxidation mechanisms, premixed and diffusion laminar flames, two-phase-flows, turbulence and turbulent combustion, pollutant formation, development of sustainable combustion technologies for power generation, shipping and aviation.


Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Literature
Teaching language, assignments and lecture slides in English


151-0221-00L  Introduction to Modeling and Optimization of Sustainable Energy Systems  W  4 credits  4G  G. Sansavini, A. Bardow

Abstract
This course introduces the fundamentals of energy system modeling for the analysis and the optimization of the energy system design and operations.

Objective
At the end of this course, students will be able to:
- define and quantify the key performance indicators of sustainable energy systems;
- select and apply appropriate models for conversion, storage and transport of energy;
- develop mathematical models for the analysis, design and operations of multi-energy systems and solve them with appropriate mathematical tools;
- select and apply methodologies for the uncertainty analysis on energy systems models;
- apply the acquired knowledge to tackle the challenges of the energy transition.

In the course "Introduction to Modeling and Optimization of Sustainable Energy Systems", the competencies of process understanding, system understanding, modeling, concept development, data analysis & interpretation and measurement methods are taught, applied and examined. Programming is applied.

Content
The global energy transition; Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

Lecture notes
Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

151-0109-00L  Turbulent Flows  W  4 credits  2V+1U  P. Jenny

Abstract
Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling

Objective
- Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scalars. Homogeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows

Content
- Properties of laminar, transitional and turbulent flows.
- Origin and control of turbulence. Instability and transition.
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.
- Scalars. Homogeneous isotropic turbulence, energy spectrum.
- Turbulent free shear flows. Jet, wake, mixing layer.
- Wall-bounded turbulent flows.
- Turbulent flow computation and modeling.

Lecture notes
Lecture notes are available

Literature

151-0913-00L  Introduction to Photonics  W  4 credits  2V+2U  R. Quidant, J. Ortega Arroyo

Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
- Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Class notes and handouts</th>
<th>Literature</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>I- BASICS OF WAVE THEORY</td>
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<td></td>
<td>1) General concepts</td>
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<td></td>
<td>2) Differential wave equation</td>
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<td>3) Wavefront</td>
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<td>4) Plane waves and Fourier decomposition of optical fields</td>
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<td>5) Spherical waves and Huygens-Fresnel principle</td>
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<td>II- ELECTROMAGNETIC WAVES</td>
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<td>1) Maxwell equations</td>
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<td>2) Wave equation for EM waves</td>
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<td>3) Dielectric permittivity</td>
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<td>4) Refractive index</td>
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<td>5) Nonlinear optics</td>
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<td>6) Polarisation and polarisation control</td>
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<td>III- PROPAGATION OF LIGHT</td>
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<td>1) Waves at an interface</td>
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<td>2) The Fresnel equations</td>
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<td>3) Total internal reflection</td>
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<td>4) Evanescent waves</td>
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<td>5) Dispersion diagram</td>
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<td>IV- INTERFERENCES</td>
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<td>1) General considerations</td>
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<td>2) Temporal and spatial coherence</td>
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<td>3) The Young double slit experiment</td>
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<td>4) Diffraction gratings</td>
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<td>5) The Michelson interferometer</td>
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<td>6) Multi-wave interference</td>
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<td>7) Antireflecting coating and interference filters</td>
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<td>8) Optical holography</td>
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<td>V- LIGHT MANIPULATION</td>
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<td>1) Optical waveguides</td>
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<td>2) Photonic crystals</td>
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<td>3) Metamaterials and metasurfaces</td>
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<td>4) Optical cavities</td>
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<td>VI- INTRODUCTION TO OPTICAL MICROSCOPY</td>
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<td>1) Basic concepts</td>
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<td>2) Direct and Fourier imaging</td>
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<td>3) Image formation</td>
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<td>4) Fluorescence microscopy</td>
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<td>5) Scattering-based microscopy</td>
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<td>6) Digital holography</td>
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<td></td>
<td>7) Computational imaging</td>
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<td>VII- OPTICAL FORCES AND OPTICAL TWEEZERS</td>
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<td></td>
<td>1) History of optical forces</td>
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<td>2) Theory of optical trapping</td>
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<td>3) Atom cooling</td>
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<td>4) Optomechanics</td>
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<td>5) Plasmonic trapping</td>
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<td></td>
<td>6) Applications of optical tweezers</td>
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</tbody>
</table>

| 151-0917-00L  | Mass Transfer            | W  | 4 credits | 2V+2U | S. E. Pratsinis, V. Mavrantzas, C.-J. Shih |

**Abstract**

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

**Objective**

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

**Content**

- Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

**Literature**


**Prerequisites / notice**

Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

| 151-0973-00L  | Introduction to Process Engineering | W  | 4 credits | 2V+2U | F. Donat, C. Müller |

**Abstract**

Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multistage systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

**Objective**

We teach the fundamentals of process engineering using practical examples as well as concrete process engineering problems in the areas of process control and balancing, thermal separation processes, mechanical separation processes and reaction engineering.
Overview of process engineering; fundamentals of process engineering; processes and balances; overview of thermal separation processes and multiphase systems; overview of mechanical separation processes and granular systems; introduction into reaction engineering, reactors and residence times.

In addition to teaching basic theoretical knowledge, the focus is on solving typical problems in various subdisciplines of process engineering.

A script is provided (German language).

Further literature will be announced during the course. For the successful completion of the course, the lecture notes, the slides of the lecture and the exercise materials are sufficient.

The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.


Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

A script is provided (German language).

Does not take place this semester.

This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

Microsystems I: Process Technology and Integration
151-0621-00L

W 6 credits 3V+3U M. Haluska, C. Hierold

Abstract
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of Microsystems and -devices by a sequence of defined processing steps (process flow).

Objective
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (= process flow).

Content
- Introduction to Microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific Microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.
Application of selected technologies will be demonstrated on case studies.

Lecture notes
Handouts (available online)

Literature
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Studies on Mechatronics
151-0640-00L

W 5 credits 11A

Abstract
Overview of Mechatronics topics and study subjects. Identification of minimum 10 pertinent refereed articles or works in the literature in consultation with supervisor or instructor. After 4 weeks, submission of a 2-page proposal outlining the value, state-of-the-art and study plan based on these articles. After feedback on the substance and technical writing by the instructor, project commences.

Objective
The students are familiar with the challenges of the fascinating and interdisciplinary field of Mechatronics and Microsystems. They are introduced to the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Content
The students work independently on a study of selected topics in the field of Mechatronics or Microsystems. They start with a selection of scientific papers to continue literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

Introduction to Photonics
151-0913-00L

W 4 credits 2V+2U R. Quidant, J. Ortega Arroyo

Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photons, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes: Class notes and handouts
Literature: Optics (Hecht) - Pearson
Prerequisites / notice: Physics I, Physics II

227-0113-00L Power Electronics W 6 credits 4G J. W. Kolar
Abstract
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Objective
Fields of application of power electronic converters; basic concept of switch-mode voltage and current conversion; derivation of circuit structures of non-isolated and isolated DC/DC converters, AC/DC- and DC/AC converter structures; analysis procedure and analysis of the operating behaviour and operating range; design criteria and design of main power components.

Content
Fields of application and application examples of power electronic converters, basic concept of switch-mode voltage and current conversion, pulse-width modulation (PWM); derivation and operating modes (continuous and discontinuous current mode) of DC/DC converter topologies, buck / boost / buck-boost converter; extension to DC/AC conversion using differences of unipolar output voltages varying over time; single-phase diode rectifier; boost-type PWM rectifier featuring sinusoidal input current; tolerance band AC current control and cascaded output voltage control with inner constant switching frequency current control; local and global averaging of switching frequency discontinuous quantities for calculation of component stresses; three-phase AC/DC conversion, center-tap rectifier with impressed output current, thyristor function, thyristor center-tap and full-bridge converter, rectifier and inverter operation, control angle and recovery time, inverter operation limit; basics of inductors and single-phase transformers, design based on scaling laws; isolated DC/DC converter, flyback and forward converter, single-switch and two-switch circuit; single-phase DC/AC conversion, four-quadrant converter, unipolar and bipolar modulation, fundamental frequency model of AC-side operating behaviour; three-phase DC/AC converter with star-connected three-phase load, zero sequence (common-mode) and current forming differential-mode output voltage components, fundamental frequency modulation and PWM with singe triangular carrier and individual carrier signals of the phases.

Lecture notes: Lecture notes and associated exercises including correct answers, simulation program for interactive self-learning including visualization/animation features.
Prerequisites / notice: Prerequisites: Basic knowledge of electrical engineering / electric circuit analysis and signal theory.
This course introduces different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Lecture notes: Lecture notes and associated exercises including correct answers.
Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and design safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement a human-interactive control strategy on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of development control strategies including impedancematch/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical-human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here, the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/_virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

The lecture notes will be distributed on Moodle before the lectures.

Literature


Prerequisites / notice
The registration is limited to 26 students.
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.

http://www.relab.ethz.ch/education/courses/phri.html

Microsystems and Nanoscale Engineering
Focus Coordinator: Prof. Christofer Hierold

Number Title Type ECTS Hours Lecturers
151-0621-00L Microsystems I: Process Technology and Integration W 6 credits 3V+3U M. Haluska, C. Hierold

ECTS
376-1504-00L Physical Human Robot Interaction (PHRI) W 4 credits 2V+2U O. Lambercy

Autumn Semester 2022

Data: 01.11.2022 12:41
The students get familiarized with the challenges of the fascinating and interdisciplinary field of Micro- and Nanosystems. They are

Analytical Competencies
Fostered competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

Objective
Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps ( = process flow).

Content
- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.

Application of selected technologies will be demonstrated on case studies.

Lecture notes
Handouts (available online)

Literature
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

Prerequisites / notice
Prerequisites: Physics I and II

151-0509-00L Acoustics in Fluid Media: From Robotics to Additive Manufacturing
W 4 credits 3G D. Ahmed

Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

Lecture notes

Literature

Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.

151-0604-00L Microrobotics
W 4 credits 3G B. Nelson

Abstract
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

151-0643-00L Studies on Micro and Nano Systems
W 5 credits 11A Supervisors

Abstract
This course is not available to incoming exchange students.

Objective
The students get familiarized with the challenges of the fascinating and interdisciplinary field of Micro- and Nanosystems. They are introduced to the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Content
The students get familiarized with the challenges of the fascinating and interdisciplinary field of Micro- and Nanosystems. They are introduced to the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Students work independently on a study of selected topics in the field of Micro- and Nanosystems. They start with a selection of scientific papers, and continue with an independent literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.
Abstract

This course aims to familiarize motivated M/BSc students with some of the basic phenomena of particles at the nanoscale, thereby illustrating the links between physics, chemistry, materials science through hands-on experience. Furthermore it aims to give an overview of the field with motivating lectures from industry and academia, including the development of technologies and processes based on particle technology with introduction to design methods of mechanical processes, scale-up laws and optimal use of materials and energy. Most importantly, this course aims to develop the creativity and sharpen the communication skills of motivated students through their individual projects, a PERFECT preparation for the M/BSc thesis (e.g. efficient & critical literature search, effective oral/written project presentations), the future profession itself and even life, in general, are always there!

Content

The course objectives are best met primarily through the individual student projects which may involve experiments, simulations or critical reading. Students from a diverse set of science and engineering backgrounds. The course is conducted individually under the close supervision of MSc, PhD or post-doctoral students. Therein, a 2-page proposal is submitted within the first two semester weeks addressing explicitly, at least, 10 well-selected research articles and thoughtful meetings with the project supervisor. The proposal address 3 basic questions: a) how important is the project; b) what has been done already in that field and c) what will be done by the student. Detailed feedback on each proposal is given by the supervisor, assistant and professor two weeks later. Towards the end of the semester, a 10-minute oral presentation is given by the student followed by 10 minutes Q&A. A 10-page final report is submitted by noon of the last day of the semester. The project supervisor will provide guidance throughout the course. Lectures include some of the following:

- Overview & Project Presentation
- Particle Size Distribution
- Particle Diffusion
- Coagulation
- Agglomeration & Coalescence
- Particle Growth by Condensation
- Control of particle size & structure during gas-phase synthesis
- Multi-scale design of aerosol synthesis of particles
- Particle Characterization
- Aerosol manufacture of nanoparticles
- Forces acting on Single Particles in a Flow Field
- Fixed and Fluidized Beds
- Separations of Solid-Liquid & Solid-Gas systems
- Emulsions/droplet formation/microfluidics
- Gas Sensors
- Coaching for proposal & report writing as well as oral presentations

Literature

FluidMechanik I, Thermodynamik I & II & "clean" 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As exceptional effort will be required! Having seen “Chasing Mavericks” (2012) by Apted & Henson, “Unbroken” (2014) by Angelina Jolie and, in particular, “The Salt of the Earth” (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).

Prerequisites / notice

Additional ones could be enrolled by permission of the lecturer.

Number of participants is limited to 20.

151-0913-00L Introduction to Photonics

Abstract

This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course will help students develop an understanding of the field with motivating lectures from industry and academia, including the development of technologies and processes based on particle technology with introduction to design methods of mechanical processes, scale-up laws and optimal use of materials and energy. Most importantly, this course aims to develop the creativity and sharpen the communication skills of motivated students through their individual projects, a PERFECT preparation for the M/BSc thesis (e.g. efficient & critical literature search, effective oral/written project presentations), the future profession itself and even life, in general, are always there!

Content

The course objectives are best met primarily through the individual student projects which may involve experiments, simulations or critical reading. Students from a diverse set of science and engineering backgrounds. The course is conducted individually under the close supervision of MSc, PhD or post-doctoral students. Therein, a 2-page proposal is submitted within the first two semester weeks addressing explicitly, at least, 10 well-selected research articles and thoughtful meetings with the project supervisor. The proposal address 3 basic questions: a) how important is the project; b) what has been done already in that field and c) what will be done by the student. Detailed feedback on each proposal is given by the supervisor, assistant and professor two weeks later. Towards the end of the semester, a 10-minute oral presentation is given by the student followed by 10 minutes Q&A. A 10-page final report is submitted by noon of the last day of the semester. The project supervisor will provide guidance throughout the course. Lectures include some of the following:

- Overview & Project Presentation
- Particle Size Distribution
- Particle Diffusion
- Coagulation
- Agglomeration & Coalescence
- Particle Growth by Condensation
- Control of particle size & structure during gas-phase synthesis
- Multi-scale design of aerosol synthesis of particles
- Particle Characterization
- Aerosol manufacture of nanoparticles
- Forces acting on Single Particles in a Flow Field
- Fixed and Fluidized Beds
- Separations of Solid-Liquid & Solid-Gas systems
- Emulsions/droplet formation/microfluidics
- Gas Sensors
- Coaching for proposal & report writing as well as oral presentations

Literature

FluidMechanik I, Thermodynamik I & II & "clean" 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As exceptional effort will be required! Having seen “Chasing Mavericks” (2012) by Apted & Henson, “Unbroken” (2014) by Angelina Jolie and, in particular, “The Salt of the Earth” (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics I, Physics II

Additional Case for the Focus Specialization
151-0135-00L Manufacturing I

W+ 4 credits 2V+2U K. Wegener, M. Wiessner

Abstract
Deeper insight in manufacturing processes: drilling, milling, grinding, honing, lapping, electro erosion and electrochemical machining.

Stability of processes, process chains and process choice.

Objective
Deeper discussion on the machining processes and their optimisation. Outlook on additional areas such as NC-Technique, dynamics of processes and machines, chatter as well as process monitoring.

Content
Deepened insight in the machining processes and their optimisation, chip removal by undefined cutting edge such as grinding, honing and lapping, machining processes without cutting edges such as EDM, ECM, outlook on additional areas as NC-technique, machine- and process dynamics including chatter and process monitoring.

Lecture notes
yes

Prerequisites: Recommendation: Lecture 151-0700-00L Manufacturing elective course in the 4th semester.

Language: Help for English speaking students on request as well as english translations of the slides shown.

151-0733-00L Basics and Processes of Metal Forming

W+ 4 credits 2V+2U M. Bambach

Note: The previous course title until HS21 "Forming"
The lecture teaches on the basic knowledge of major processes in sheet metal, tube and bulk metal forming technologies. In particular it focuses on fundamental computation methods, which allow a fast assessment of process behaviour and a rough layout. Process-specific states of stress and deformation are analysed and process limits are identified.

Objective

Acquaintance with forming processes. Determination of forming processes. Interpretation of forming manufacturing techniques for joining objects and design of joining equipment.

Content

The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, ro extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.

Lecture notes

ja

151-0703-00L Operational Simulation of Production Lines W 4 credits 2V+1U P. Acél

Abstract

The students learn the application of the event-driven and computer-based simulation for layout and operational improvement of production facilities by means of practical examples. The simulation provides an essential basis for digital twins in Industry 4.0. Operating simulation in the productions, logistic and scheduling will be shown by means of practical examples.

Objective

The students should make their first experiences in the use of computer-based simulation.

Content

- Application and application areas of the event-driven simulation
- Simulation in the context of Industry 4.0 (digital twin)
- Exemplary application of a software tool (Technomatix-Simulation-Software)
- Internal organisation and functionality of simulation tools
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting

The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example.

Lecture notes

Will be sent by email before the lecture (pdf).

Literature

A bibliography will be given during the lectures.

Prerequisites / notice

Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (NAVT, MTEC).

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed
Sensitivity to Diversity assessed

Social Competencies
Cooperation and Teamwork assessed
Customer Orientation assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

151-0717-00L Mechanical Production: Assembly, Joining and Coating Technology W 4 credits 2V+1U K. Wegener, V. H. Derflinger, P. Jousset

Abstract

Understanding of the complexity of the assembly process as well as its meaning as success and cost factor. The assembly with the different aspects of adding, moving, adjusting, controlling parts etc., adding techniques; solvable and unsolvable connections. Assembly plants. Coating techniques and their tasks, in particular corrosion protection.

Objective

To understand assembly in its full complexity and its paramount importance regarding cost and financial success. An introduction into a choice of selected joining and coating techniques.

Content

- Assembly as combination of several classes of action like, e.g., joining, handling, fine adjustments, etc. Techniques for joining objects temporarily or permanently. Assembly systems.
- Coating processes and their specific applications, with particular emphasis on corrosion protection.

Lecture notes

Yes

Prerequisites / notice

Recommended to the focus production engineering. Majority of lecturers from the industry.

151-0719-00L Quality of Machine Tools - Dynamics and Metrology at Micro and Submicro Level W 4 credits 2V+1U A. Günther, D. Spescha

Abstract

The course “Machine tool metrology” deals with the principal design of machine tools, their spindles and linear axes, with possible geometric, kinematic, thermal and dynamic errors of machine tools and testing these errors, with the influence of errors on the workpiece (error budgeting), with testing of drives and numerical control, as well as with checking the machine tool capability.

Objective

Knowledge of
- principal design of machine tools
- errors of linear and rotational axes and of machine tools,
- influence of errors on the workpiece (error budgeting)
- dynamics of mechanical systems
- measurement data acquisition / digital signal analysis
- experimental modal analysis
- geometric, kinematic, thermal, dynamic testing of machine tools
- test uncertainty
- machine tool capability

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1592 of 2416
The lecture follows the value added process sequence of electric and electronic components. It contains: Development of electric and electronic circuits, design of electronic circuits on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electronic on a wafer as well as recycling.

Knowledge about the value added process sequence for electronics manufacturing, planning of electric and electronic product as well as their production, planning of production lines, value added process sequence for photovoltaics.

The lecture starts with a brief introduction of electronic components and the planning of integrated circuits. Next, an overview will be provided about electronic functional units assembled from these electronic components, on printed circuit boards as well as in hybrid technology. Value added process steps are shown as well as their quality check and their combination for planning a complete manufacturing line. The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics will described too.

The lecture concludes with an excursion to a large manufacturing company. Here, students can the see the application and realization of the manufacturing of electric and electronic devices.

Documents are provided during the course. English handouts available on request.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0509-00L</td>
<td>Acoustics in Fluid Media: From Robotics to Additive Manufacturing</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>D. Ahmed</td>
</tr>
<tr>
<td></td>
<td>Note: The previous course title until HS21 &quot;Microscale Acoustofluidics&quot;</td>
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<tr>
<td>Abstract</td>
<td>The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.</td>
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<tr>
<td>Objective</td>
<td>The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.</td>
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<tr>
<td>Content</td>
<td>Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories, Techniques and Technologies</td>
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<tr>
<td></td>
<td>Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving</td>
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<tr>
<td></td>
<td>Personal Competencies: Critical Thinking, Integrity and Work Ethics, Self-direction and Self-management</td>
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<tr>
<td>151-0524-00L</td>
<td>Continuum Mechanics I</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>A. E. Ehret</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.</td>
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<tr>
<td>Objective</td>
<td>Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.</td>
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<tr>
<td>Content</td>
<td>Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments</td>
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<tr>
<td>Lecture notes</td>
<td>Yes</td>
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<tr>
<td>151-0604-00L</td>
<td>Microrobotics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Nelson</td>
</tr>
<tr>
<td>Abstract</td>
<td>Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.</td>
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<tr>
<td>Objective</td>
<td>The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.</td>
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<tr>
<td>Content</td>
<td>Main topics of the course include: - Scaling laws at micro/nano scales - Electrostatics - Electromagnetism - Low Reynolds number flows - Observation tools - Materials and fabrication methods - Applications of biomedical microrobots</td>
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<tr>
<td>Lecture notes</td>
<td>The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The lecture will be taught in English.</td>
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<tr>
<td>151-0621-00L</td>
<td>Microsystems I: Process Technology and Integration</td>
<td>W</td>
<td>6</td>
<td>3V+3U</td>
<td>M. Haluska, C. Hierold</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students are introduced to the fundamentals of semiconductors, the basics of micromaniching and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).</td>
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<tr>
<td>Objective</td>
<td>Students are introduced to the basics of micromaniching and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (+ process flow).</td>
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<tr>
<td>Content</td>
<td>- Introduction to Microsystems technology (MST) and micro electro mechanical systems (MEMS) - Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition. - Specific microsystems technologies: Bulk and surface micromaniching, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties. Application of selected technologies will be demonstrated on case studies.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts (available online)</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Physics I and II</td>
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</tbody>
</table>
The students are familiar with the challenges of the fascinating and interdisciplinary field of Engineering for Health. They are introduced in Lecture notes and handouts. This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to supervise the students.

Abstract
Overview of Engineering for Health topics. Identification of minimum 10 pertinent refereed articles or works in the literature in consultation with supervisor or instructor. After 4 weeks, submission of a 2-page proposal outlining the value, state-of-the-art and study plan based on these articles. After feedback on the text and technical writing by the instructor, project commences.

Objective
The students are familiar with the challenges of the fascinating and interdisciplinary field of Engineering for Health. They are introduced in Lecture notes and handouts. This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to supervise the students.

Content
The students work independently on a study of selected topics in the field of Studies on Engineering for Health. They start with a selection of scientific papers to continue literature research. The results (e.g. state-of-the-art, methods) are evaluated with respect to predefined criteria. Then the results are presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

Literature
Will be available.

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The paradox of International funding

Biases academic publishing

The emerging role in Global Philanthropy

The paradox of International funding

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After completing the course, participants will be able to

• critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world”

• “developing” “global south” “low and middle-income” and justify their own chosen terminology

• understand the political, financial, and cultural reasons why technology and infrastructure have historically failed

• Debate the merits of international engineering in popular culture and media

• Propose improved SDG indicators that address current shortcomings

• Compare the engineering curricula of different countries to identify relative strengths and shortcomings

• Explain the inherent biases of academic publishing and its impact on engineering failure

• Analyse linkages between the rise of philanthropy and strategic priorities

• Recommend equitable, just funding models to achieve more sustainable outcomes

• Formulate a vision for the international engineer of the future

Content
Role of international engineering during colonialism

Transition of international engineering following colonialism

White saviourism and racism in international engineering

International engineering in popular culture

The missing role of Engineering Education

Biases academic publishing

The emerging role in Global Philanthropy

The paradox of International funding

Literature


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Upon completion of the course students are able to:

• Explain the physical and mathematical foundations of diagnostic medical imaging systems

• Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function

• Design a basic diagnostic imaging system chain including data acquisition and data reconstruction

• Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Content
Introduction (intro, overview, history)

Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)

X-rays (production, tissue interaction, contrast, modular transfer function)

X-rays (resolution, detection, digital subtraction angiography, Radon transform)

X-rays (filtered back-projection, spiral computed tomography, image quality, dose)

Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PET)

Nuclear imaging (detection principles, image reconstruction, kinetic modelling)

Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)

Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)

Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)

Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)

Ultrasound (spatial and temporal resolution, phased arrays)

Ultrasound (Doppler shift, implementations, applications)

Summary, example exam questions

Lecture notes

Lecture notes and handouts

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Webb A, Smith N.B. Introduction to Medical Imaging: Physics, Engineering and Clinical Applications; Cambridge University Press 2011

Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1595 of 2416
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

Lecture topics:

1. Introduction
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
5. Detection and Noise
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics

The course requires an open attitude to the interdisciplinary approach of bioelectronics. In addition, it requires undergraduate entry-level familiarity with electric & magnetic fields/forces, resistors, capacitors, electric circuits, differential equations, calculus, probability calculus, Fourier transformation & frequency domain, lenses / light propagation / refractive index, pressure, diffusion AND basic knowledge of biology and chemistry (e.g. understanding the concepts of concentration, valence, reactants-products, etc.).
376-0203-00L Movement and Sport Biomechanics W 4 credits 3G B. Taylor, R. List

Abstract

Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.

Objective

Students are able to describe the human body as a mechanical system.

They analyse and describe human movement according to the laws of mechanics.

Content

Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.

376-1504-00L Physical Human Robot Interaction (pHRI) ■ W 4 credits 2V+2U O. Lambercy

Abstract

This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

Objective

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de- sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

Content

This course provides an introduction to the fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes

Will be distributed on Moodle before the lectures.

Literature


The course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing. This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the processes and systems that transform inputs into outputs and deliver products and services to customers. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

Course structure:
- **Prerequisites / Notice:**
  - The registration is limited to 26 students.
  - There are 4 credit points for this lecture.
  - The lecture will be held in English.
  - The students are expected to have basic control knowledge from previous classes.
- **Abstract:**
  - Introduction to molecules used for biomaterials; molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.
- **Objective:**
  - The course covers the following topics:
    1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
    2. The concept of biocompatibility.
    3. Introduction into methodology used in biomaterials research and application.
    4. Introduction to different material classes in use for medical applications.
- **Content:**
  - Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated.
  - Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.
  - A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.
- **Lecture notes / Literature:**
  - Handouts are deposited online (moodle).
  - Literature:
    - (available online via ETH library)
  - Handouts and references therein.

**Management, Technology and Economics**

*Focus Coordinators: Prof. Stefano Brusoni D-MTEC and Swantje Pless D-MTEC*

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
151-0733-00L | Basics and Processes of Metal Forming | W | 4 credits | 2V+2U | M. Bambach
---|---|---|---|---|---
363-0445-00L | Production and Operations Management | W+ | 3 credits | 2G | T. Netland, H. Franke

**Abstract**
- This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.
- After completing this course:
  1. Students can apply key concepts of POM to detail an operations strategy.
  2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
  3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
  4. Students can choose IT, OT, and automation technology for manufacturing applications.
  5. Students can design information flows, manage master data, and use it to plan and control a factory.
  6. Students can design material flows in and beyond factories.
  7. Students can design performance management systems.
  8. Students can select and use problem-solving tools to improve quality and productivity.
  9. Additional skills: Students acquire experience in teamwork.

**Content**
- The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).
- Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow,Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
- Video lectures. Short video lectures presenting basic POM concepts.
- Class lectures. Deep-dives with case examples on select topics.
- FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
- Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.
Literature

Suggested literature is provided in the syllabus.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

363-0541-00L Systems Dynamics and Complexity

Abstract
Finding solutions: what is complexity, problem solving cycle.
Implementing solutions: project management, critical path method, quality control feedback loop.
Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

Objective
A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

Content
Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.
The course is structured along three main tasks:
1. Finding solutions
2. Implementing solutions
3. Controlling solutions
PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.
PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.
PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.
Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see “Prerequisites”).

Lecture notes
The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture

363-0541-02L Systems Dynamics and Complexity (Additional Cases)

Abstract
Only for Mechanical Engineering BSc.

Objective
MAVT Bachelor students learn how to develop and analyze more sophisticated systems dynamics models from different areas, e.g. from biology (population dynamics, cooperation), management (inventory modeling, technology adoption and economics (supply and demand, investment and consumption), to name but a few. The goal is to apply analytical and numeric techniques to gain a deeper understanding of the dynamics of complex systems.
1. Modelling path dependence and formation of standards
   - Why do clocks go clockwise? Why do people in most nations drive on the right? Why do nearly all computer keyboards have the QWERTY layout, even though it is more inefficient compared to DVORAK? It turns out that many real-world processes are path dependent, i.e. small random events early in their history determine the ultimate end state, even when all end states are equally likely at the beginning. Students will learn how to model such processes, to understand the feedback mechanisms that lead to path dependence. As a case in point, we will study the ‘war’ between the Betamax and the VHS standards.

2. Optimal migration as promoter of cooperation
   - Mechanisms to promote cooperative behaviour is a vibrant research topic in various fields - economics, evolutionary biology and management science to name but a few. Students will be introduced to one such mechanism - migration. They will develop and analyse a macroscopic model to study how the rate of migration affects the long-term cooperation rate in a population.

3. Information transfer
   - Information flow in a social system (e.g. about the location of resources or appearance of a competitor) is an important component of group living. For example, it is well known that ants can achieve remarkable feats in finding an optimal route to a food patch through pheromone trails. The goal of this study case is to model information transfer in such systems by investigating the dynamics of trail formation in ants. The students will learn that the complexity in navigating to a food source may nevertheless be explained as a simple dynamical system with one control parameter only.

4. Decisions in social societies
   - In many situations individuals have to decide between two or more options. Such decisions often have a profound impact on the system as a whole, especially regarding group cohesion. Group cohesion is preferred, as individuals can benefit from living in groups, yet it may not be the underlying reason behind individual choices. In this case, students will develop and extend a macroscopic model of an animal social system faced with a decision to choose a new home, and identify the conditions which promote group cohesion versus group splitting.

5. Antigenic variation of HIV
   - One of the characteristic traits of HIV is that a host can be a carrier and a transmitter of the virus without experiencing symptoms for up to 10 years. This case is concerned with finding the mechanism of HIV disease progression. The students will develop a general population-based model for the interaction of an infectious agent with the host immune system. The model is applicable to a variety of infectious agents, ranging from acute lethal infections to chronic illness. Through analysing and simulating the model, the students will understand how the HIV virus interacts with the host and how the mutation rate of the virus is ultimately responsible for this long asymptomatic period.

6. Compartmental models in epidemiology
   - Many diffusive processes in social systems, such as epidemics, can be understood as a result of the interaction between a few groups (compartments) of individuals. The most common example is to divide a population into those who are susceptible (S) to a disease, those who are infected (I), and those who have recovered (R) and are immune, and to model their interactions. These so called SIR models find wide application in studying non-biological diffusive processes, e.g. spread of technological innovations, fads, internet memes etc. In this study case, students will become familiar with the basic components of an SIR model and the conditions under which a disease can cause the outbreak of an epidemic. Students will extend the basic model to investigate more realistic scenarios relevant to e.g. different vaccination strategies.

Lecture notes
Will be provided
Analytical Competencies
1 credit
J. Meuer, A. Nunez-Jimenez

Content
Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

Literature
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00L, "Discovering Management".

Fostered competencies

- Analytical Competencies are assessed.

Corporate Sustainability
363-0387-00L

Abstract
The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

Objective
- Students are assessed.

3 credits

Content
In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share his insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

Lecture notes
Presentation slides will be made available on Moodle prior to lectures.

Literature
http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

Technology and Innovation Management
363-0389-00L

Abstract
This course focuses on the analysis of innovation as a pervasive process that cuts across organizational and functional boundaries. It looks at the sources of innovation, at the tools and techniques that organizations deploy to routinely innovate, and the strategic implications of technical change.

Objective
- Students are assessed.

3 credits

Content
This course looks at technology and innovation management as a process. Continuously, organizations are faced with a fundamental decision: they have to allocate resources between well-known tasks that reliably generate positive results; or explore new ways of doing things, new technologies, products and services. The latter is a high risk choice. Its rewards can be high, but the chances of success are small.

Lecture notes
Slides will be available on the Moodle page

Literature
Readings will be available on the Moodle page

Fostered competencies

- Analytical Competencies are assessed.

Technology and Innovation Management (Additional Cases)
363-0389-02L

Abstract
This module focuses on the topics that lie at the intersection between management and engineering.
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

The course Accounting for Managers offers an introduction to financial accounting and management accounting. It provides managers with the necessary knowledge for decision making using accounting information.

This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Objective

By attending this course, students will be able to:
- record business transactions on the different types of accounts.
- establish a balance sheet and an income statement.
- prepare the different financial reports.
- understand the principles of cost accounting.
- determine the cost of production.
- make decisions based on cost information.

This course is a prerequisite for the course Financial Management.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Module</th>
<th>Notice</th>
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<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td></td>
</tr>
<tr>
<td>363-0711-00L</td>
<td>Accounting for Managers</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>H. Chen</td>
</tr>
</tbody>
</table>
| 363-0790-00L | Technology Entrepreneurship         | W    | 2       | 2V     | F. Hacklin


This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

Fostered Competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Technics and Technologies: not assessed

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: not assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

Techniques and Technologies

- Data: 01.11.2022 12:41
- Autumn Semester 2022
- Page 1602 of 2416
A. Sethi

12 sessions; 10+ carried out by guest speakers: experts in the broad field of technology entrepreneurship (e.g., serial entrepreneurs, venture capitalists, (E)MBA professors, company builders, patent experts, scale-up executives, …)

2h lecture - schedule (±):
15': Introduction
60': (Guest) lecture
15': Discussion related to topic (in groups)
10': Plenary discussion
20': Q&A with (guest) lecturer

Sessions are carried out via zoom, recordings are uploaded on Moodle. Sessions can also be followed in reserved lecture room.

Semester assignment: Construction of 1 appropriate exam question (MPC) related to a specific guest lecture.

13th session: MPC exam, heavily based on questions generated from the semester assignment. These will be published on Moodle as a preparation for the exam.

See course website: http://www.entrepreneurship.ethz.ch/education/fall/technology-entrepreneurship.html

### Lecture notes

**Lecture slides and case material**

#### 363-1082-00L Enabling Entrepreneurship: From Science to Startup

**W 3 credits 2V A. Sethi**

*Students should provide a brief overview (unto 1 page) of their business ideas that they would like to commercialise through the course. If they do not have an idea, they are required to provide a motivation letter stating why they would like to do this elective. If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.*

The total number of students will be limited to 50.

The students should submit the necessary information until 19 September 2022 and apply to anilsethi@ethz.ch

#### Abstract

This elective is relevant for students who have developed a technology and are keen to evaluate the steps in starting a startup. This is also relevant for students who would like to start a startup but do not have a technology, but are clear on a specific market and the impact they would like to create.

#### Objective

Students have technology competence or an idea that they would like to convert into a startup. They are now in the process of evaluating the steps necessary to do so. In summary:

1. Students want to become entrepreneurs
2. The students can be from business or science & technology
3. The course will enable the students to identify the relevance of their technology or idea from the market relevance perspective and thereby create a business case to take it to market.
4. The students will have exposure to investors and entrepreneurs (with a focus on ETH spin-offs) through the course, to gain insight to commercialise their idea

#### Content

The students would cover the following topics, as they build their idea into a business case:

1. Technology excellence: this assumes that the student has achieved a certain degree of competence in the area of technology that he or she expects to bring to the market
2. Market need and market relevance: The student would then be expected to identify the possible markets that may find the technology of relevance. Market relevance implies the process of identification of how relevant the market perceives the technology, and whether this can sustain over a longer period of time
3. IP and IP strategy: Intellectual property, whether in the form of a patent or a trade secret, implies the secret ingredient that enables the student to achieve certain results that competitors are unable to copy. This enables the student (and subsequently the startup) to hold on to the market that they create with customers
4. Team including future capabilities required: a startup requires multiple people with complementary capabilities. They also need to be motivated while at the same time protecting the interests of the startup.
5. Financials: There is a need of funding to achieve milestones. This includes funding for salaries and running of the company
6. Investors and funding options: There are multiple funding options for a startup. They all come with different advantages and limitations. It's important for a startup to recognize its needs and find the investors that fit these needs and are best aligned with the vision of the founders
7. Preparation of business case: The students will finally prepare the business case that can help them to articulate the link of the technology with the market need and its willingness to pay
8. Legal overview, company forms and shareholders’ agreements (including pitfalls)

The seminar includes talks from invited investors, entrepreneurs and legal experts regarding the importance of the various elements being covered in content, workshops and teamwork. There is a particular emphasis on market validation on each step of the journey, to ensure relevance.

#### Lecture notes

Since the course will revolve around the ideas of the students, the notes will be for the sole purpose of providing guidance to the students to help convert their technologies or ideas into business cases for the purpose of forming startups. Theoretical subject matter will be kept to a minimum and is not the focus of the course.

#### Literature

Book
Sethi, A. “From Science to Startup”
ISBN 978-3-319-30422-9

#### Prerequisites / notice

This course is relevant for those students who aspire to become entrepreneurs.

Students applying for this course are requested to submit a 1 page business idea or, in case they don't have a business idea, a brief motivation letter stating why they would like to do this course.

If you are unsure about the readiness of your idea or technology to be converted into a startup, please drop me a line to schedule a call or meeting to discuss.
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
1) individual decision making under risk
2) models of insurance demand, risk sharing, insurance supply
3) information issues in insurance markets
4) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Design, Mechanics and Materials

Focus Coordinator: Prof. Kristina Shea

In order to achieve the required 20 credit points for the Focus Specialization Design, Mechanics and Material you are free to choose any of the courses offered within the focus and are encouraged to select among those recommended. If you wish to take one of the Master level courses, you must get approval from the lecturer.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0364-00L</td>
<td>Lightweight Structures Laboratory</td>
<td>W+</td>
<td>4</td>
<td>5A</td>
<td>M. Zogg, P. Ermanni</td>
</tr>
</tbody>
</table>

Number of participants limited to 24.

Abstract
Teams of 2 to 3 students have to design, size, and manufacture a lightweight structure complying with given specifications. An aircraft wing spar prototype as well as later a second improved spar will be tested and assessed regarding to design and to structural mechanical criteria.

Objective
To develop the skills to identify and solve typical problems of the structure mechanics on a real application. Other important aspects are to foster team work and team spirit, to link theoretical knowledge and practice, to gather practical experiences in various fields related to lightweight structures such as design, different CAE-methods and structural testing.

Content
The task of each team (typically 2-2 students) is the realization of a reduced-scale aircraft wing spar, a typical load-carrying structure, with selected materials. The teams are free to develop and implement their own ideas. In this context, specified requirements include information about loads, interface to the surrounding structures.

The project is structured as described below:
- Concept development
- design of the component including FEM simulation and stability checks
- manufacturing and structural testing of a prototype in the lab
- manufacturing and structural testing of an improved component in the lab
- cost assessment
- Report

The project work is supported by selected teaching units.

Lecture notes
handouts for selected topics are available

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-3207-00L</td>
<td>Lightweight</td>
<td>W+</td>
<td>4</td>
<td>2V+2U</td>
<td>P. Ermanni, T. Tancogne-Dejean, M. Zogg</td>
</tr>
</tbody>
</table>

Abstract
The elective course Lightweight includes numerical methods for the analysis of the load carrying and failure behavior of lightweight structures, as well as construction methods and design principles for lightweight design.

Objective
The goal of this course is to convey substantiated background for the understanding and the design and sizing of modern lightweight structures in mechanical engineering, vehicle and airplane design.

Content
Lightweight design
Thin-walled beams and structures
Instability behavior of thin walled structures
Reinforced shell structures
Load introduction in lightweight structures
Joining technology
Sandwich design

Lecture notes
Script, Handouts, Exercises

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-3213-00L</td>
<td>Integrative Ski Building Workshop</td>
<td>W+</td>
<td>4</td>
<td>9P</td>
<td>K. Shea</td>
</tr>
</tbody>
</table>

To apply, please send the following information to jchapuis@ethz.ch by 31.08.2022: Letter of Motivation (one page), CV, Transcript of Records.

Abstract
This course introduces students to engineering design and fabrication by building their own skis or snowboard. Theoretical and applied engineering design skills like CAD, analysis and engineering of mechanical properties, 3D printing, laser cutting and practical handcrafting skills are acquired in the course.

Objective
The objectives of the course are to use the practical ski/board design and building exercise to gain hands-on experience in design, mechanics and materials. A selection of sustainable materials are also used to introduce students to sustainable design. The built skis/board will be mechanically tested in the lab as well as together out in the field on a ski day and evaluated from various perspectives. Students can keep their personal built skis/boards after the course.
This practical ski/board design and building workshop consists of planning, designing, engineering and building your own alpine ski or snowboard. Students learn and execute all the needed steps in the process, such as engineering design, CAD, material selection, analysis of the mechanical properties of a composite layup, fabrication, routing wood cores, 3D printing of plastic protectors, milling side walls from wood or ABS plastic, laying up the fibers from carbon, glass, basalt or flax, laminating with resins, sanding and finishing, as well as laser engraving and veneer wood inlays.

Willingness to engage in the practical building of your ski/board also beyond the course hours in the evening.
This course is designed as a two-semester class and the topics reflect the contents covered in both semesters. The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally assess and select appropriate methods to solve them. Students will be able to express engineering design problems as formal optimization problems. The exercises are MATLAB based.

Content

Lecture notes
available on Moodle.

151-3209-00L Engineering Design Optimization
Number of participants limited to 60.
Abstract
The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.
Objective
The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.
Content

327-1204-00L Materials at Work I
Abstract
This course attempts to prepare the student for a job as a materials engineer in industry. The gap between fundamental materials science and the materials engineering of products should be bridged. The focus lies on the practical application of fundamental knowledge allowing the students to experience application related materials concepts with a strong emphasis on case-study mediated learning.
Objective
Teaching goals:
- to learn how materials are selected for a specific application
- to understand how materials around us are produced and manufactured
- to understand the value chain from raw material to application
- to be exposed to state of the art technologies for processing, joining and shaping
- to be exposed to industry related materials issues and the corresponding language (terminology) and skills
- to create an impression of how a job in industry "works", to improve the perception of the demands of a job in industry

Content
This course is designed as a two-semester course and the topics reflect the contents covered in both semesters.

Lectures and case studies encompass the following topics:
- Strategic Materials (where do raw materials come from, who owns them, who owns the IP and can they be substituted)
- Materials Selection (what is the optimal material (class) for a specific application)
- Materials systems (subdivisions include all classical materials classes)
- Processing
- Joining (assembly)
- Shaping
- Materials and process scaling (from nm to m and vice versa, from mg to tons)
- Sustainable materials manufacturing (cradle to cradle)
- Recycling (Energy recovery)
- After a general part of materials selection, critical materials and materials and design four parts consisting of polymers, metals, ceramics and coatings will be addressed.
- In the fall semester the focus is on the general part, polymers and alloy case studies in metals. The course is accompanied by hands-on analysis projects on everyday materials.

Literature
Manufacturing, Engineering & Technology
Serope Kalpakjian, Steven Schmid
ISBN: 978-0131489653

Prerequisites / notice
- Profound knowledge in Physical Metallurgy and Polymer Basics and Bachelor Level by the following lectures: Metalle 1, 2; Polymere 1,2)
- Polymer Technology required (These subjects are covered at the Bachelor Level by the following lectures: Metalle 1, 2; Polymere 1,2)

5. Semester: Engineering Tools
The Engineering Tools courses are for MAVT Bachelor's degree students only.

Number Title Type ECTS Hours Lecturers
151-0005-10L Engineering Tool: Experimental Modal Analysis W 0.4 credits 1K D. Speschach

Number of participants limited to 16.
Abstract
Measuring and analysis methods for the determination of transfer functions of mechanical structures. Evaluation and preparation of the measured data for visualisation and interpretation of the dynamic behaviour.
Objective
Handling of accelerometers and force transducers, measurement of transfer functions of mechanical structures, determination and visualisation of vibration modes using practical examples, introduction to vibration theory and its fundamental terms.
Content
Visualisation of vibration modes using practical examples, introduction to vibration theory and its fundamental terms.
Lecture notes
German documents are provided during the course.
Prerequisites / notice
In the practical part of the course, the participants will carry out measurements on structures themselves and then analyse them with respect to natural frequencies and vibration modes.

151-0025-10L Engineering Tool: Introduction to CAM and Motion Simulation W 0.4 credits 1K M. Schmid

All Engineering Tools courses are for MAVT Bachelor's
Abstract Introduction of integrated CAD applications CAM (Computer Aided Manufacturing), Motion Simulation (Kinematics)

Objective The participants learn the possibilities of integrated CAD applications. The goal is to understand the procedures and the most important functions of these applications.

Content CAM (Computer Aided Manufacturing):
- Introduction to CAM
- Practical examples for 3-axe milling machine and Feature Based Machining
Motion Simulation (Kinematics/Dynamics):
- Introduction and practical examples

Prerequisites / notice
Voraussetzungen:
- CAD-Grundkenntnisse in Siemens NX (CAD 1. Semester)
- Verwenden Sie zur Durchführung der Übungen wenn möglich Ihr eigenes Laptop. Siemens NX kann im ETH IT-Shop kostenlos bestellt werden. Es stehen einige Rechner zur Verfügung.

151-0027-10L Engineering Tool: Programming with LabView All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 16.

Abstract An introduction is given to the LabView programming environment. The basic concepts of "virtual instruments" and data flow programming are presented. Computer-based exercises are solved during class. A simple electronic data acquisition module is used to demonstrate basic concepts of interface management and data acquisition.

Objective Introduction to the LabView programming environment.
Understanding of fundamental concepts: virtual instruments, data flow programming, control structures, data types etc.
Development of basic programming skills using in-class exercises on computers.

151-0030-10L Engineering Tool: Modelling and Servo Axis Control of Machine Tool Manipulators All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 30.

Abstract This course covers model building and the applied stimulation of (power-assisted axles on production machinery using MATLAB/Simulink and provides a practical example of how drive parameters may be set up, how through simulation an optimal axis design can be developed and which characteristics of a production machine can be reliably estimated in advance.

Objective The students are able to model servo axes considering all relevant components and process influences to simulate the achievable productivity.

Content 1. Introduction, complexity levels in model building for production machines.
2. Servo axis feedback control, cascade controller
3. Numerical control systems, setpoint generation
4. Simulation examples in MATLAB/Simulink
5. Outlook longitudinal model for battery electric vehicles

Lecture notes Wird abgegeben
Prerequisites / notice Prerequisites: Matlab skills; your laptop with Matlab/Simulink may be useful.

151-0032-10L Engineering Tool: Introduction to the Methods of Six Sigma Quality Control and Lean Production All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 36.

Abstract The course introduces to Six Sigma quality management and quality improvement, which aims to reduce process variation and to sustain process capability. It introduces also to the Lean production principles, aiming to reduce waste within the processes as well as aiming to a customer taked JIT pull-production.

Objective The participant gets an overview to the Operational Excellence philosophy and the working methods of these two aproaches. He learns the most important tools and the interaction of these two approaches. Introduction to the theory-specific aspects of Lean.
Content
1. Understanding the changing environment
   - Globalization, customer requirements, production systems
   - Six Sigma quality philosophy
   - Lean Manufacturing and TPS (Toyota Production System)

2. Quality management with Six Sigma
   - What is Six Sigma
   - DMAIC problem solving approach
   - Use of different control charts
   - Evaluate process capability, DPMO, Cp, Cpk, Taguchi
   - Cause-effect diagram
   - Control plan and sustainability, PDCA

3. Introduction to the Lean approach
   - TPS model, Lean goals and principles
   - A3 project management
   - The 9 types of waste
   - Value add and non value add activities
   - The 8 Lean-Tools, whereof 4
   - SS workplace organization
   - Value stream mapping (exercise), Little's law, process metrics
   - Continuous flow vs batch
   - Pull Principles, Kanban, DBR
   - Cell design
   - Linear Programming

4. Lean and Six Sigma in practice
   - How fits Lean and Six Sigma together
   - Continuous Improvement/Kaizen organization
   - Change-Management, risks
   - Inspire OPEX deployment approach

Notes will be distributed.

Literature
empfohlen:
- Rüttimann, Stöckli: Elements of Advanced Manufacturing Theory, Springer International, 2022
- Ohno: Toyota Production System - Beyond Large Scale Production, Productivity Press, New York, 1988

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
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<td></td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td>Decision-making</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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</tbody>
</table>

151-0047-00L Engineering Tool: Agile Product Development
All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 12.

Abstract
Agile product development is gaining high interest in many industries. Still, only few hardware developing firms have adopted Agile approaches into their daily development work due to inadequate trainings. Within this course, students will be introduced to the culture and mindset behind Agile by solving a practical development task in a team of 4 students.

Objective
Students shall experience and internalize the key principles and practices of Agile product development.

Content
Introduction to Agile (principles & methods), team-based development task.

Lecture notes
A digital script will be distributed.

151-0057-10L Engineering Tool: Systems Engineering for Project Work
All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 60.

Abstract
The course is about a methodical basis of systematic project work, with a focus on demanding interdisciplinary problems. The participants will be shown how to use it appropriately and correctly in their projects. This short course is based on the "Systems Engineering" (SE) method, which was developed at the ETH.

Objective
The goals of this compact course are:
- Goal-oriented identification and perception of relevant problem areas and project goal setting.
- Deduction and development of procedures for a promising project, including systematic planning of the project content.
- Development of work packages including efficient methodology
- Simple embedding of the projects in the organization, including relationships with buyers, users and securing project participation.
The participants learn about the procedures and tools that are necessary to develop technical products. The focus is on computer-based
1. Nachmittag:
- CAD refresh and top down modelling
  i. Sketch and features as well as manipulation and optimizing models.
  ii. Assembling
  iii. Drafting.
  iv. Organisation. working methods, conventions.
- To refresh already existing knowledge of CAD functionality.
  i. Sketch and features as well as manipulation and optimizing models.
- Introduction to the Team Center (Siemens PDM System)
  - TeamCenter data flow, in particular the process of creating and managing new Items and Parts, the approval procedure and creating different versions of Parts.
- The participants will learn and experiment with procedures by working on concrete examples so that they will subsequently be able to begin with independent product construction.

The following topics will be dealt with in depth in the lectures supporting the focus project (Praxiskurs): CAD-Methodology, FE calculations, motion simulation and construction methodology.

151-0059-10L  Engineering Tool: CAD-Methodology and PDM- Technology in the Focus Project

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Abstract
The participants learn about the procedures and tools that are necessary to develop technical products. The focus is on computer-based design and development and the management in an integrated software environment.

Objective
The participants will deepen their existing CAD knowledge and learn new PDM knowledge, so that these may be directly applied and used in the focus project.

- CAD refresh (Modelling, Assembling, Drafting, etc.) and CAD mythology for construction (Top-Down modelling)
- Introduction to the Team Center (Siemens PDM System)
- TeamCenter data flow, in particular the process of creating and managing new Items and Parts, the approval procedure and creating different versions of Parts.
- The participants will learn and experiment with procedures by working on concrete examples so that they will subsequently be able to begin with independent product construction.

The following topics will be dealt with in depth in the lectures supporting the focus project (Praxiskurs): CAD-Methodology, FE calculations, motion simulation and construction methodology.

Content
1. Nachmittag:
- CAD refresh and top down modelling
  - To refresh already existing knowledge of CAD functionality.
  i. Sketch and features as well as manipulation and optimizing models.
  ii. Assembling
  iii. Drafting.
  iv. Organisation. working methods, conventions.
- Top down modelling CAD
  i. Introduction to top down modelling and concept modelling
  ii. Case study of top down modelling
- 2. Nachmittag:
  - Introduction: Short introduction to PDM (What is the idea of PDM? PDM is more than the pure management of drawings!).
  - Lesson 1 - Team Center Rich Client Interface
  - Lesson 2 - TC data types
  - Lesson 3 - Construction from data in TC
  - Lesson 4 - Searching for and examining data.
- 3. Nachmittag:
  - TC application
  - Lesson 5 - Unit lists (PSE)
  - Lesson 6 - Cross-referencing
  - Lesson 7 - Data release
  - Lesson 8 - Product data examination

151-0061-10L  Engineering Tool: Scientific Writing with LaTeX and Vector Graphics

All Engineering Tools courses are for MAVT Bachelor's degree students only.

Abstract
This course provides insights into the structure and compilation of scientific papers and publications using LaTeX as well as open source software for image editing and the creation of vector graphics. LaTeX is a typesetting tool that separates text format and layout. It is widely used for reports and publications in the scientific domain.

Objective
By looking at specific examples during class you will obtain an overview on composing scientific papers (e.g. bachelor theses, semester theses, master theses) using LaTeX and acquire the most important commands to typeset complex formulas, tables and graphics.

Content
- layout of scientific reports
- writing with LaTeX (structure, formatting, formulas, tables, graphics, references, table of contents, hyperlinks, packages) based on a template for bachelor/ semester/ master theses.
- graphic design and illustration using open source software and Matlab
- including PDF files in the report (project description, data sheets)
- managing bibliography databases

Literature
http://www.relab.ethz.ch/education/courses/engineering-tools-latex.html

Prerequisites / notice
- at least two students of a Focus-Team should sign in for this course, if the use of Siemens Teamcenter PLM is given for the Team.
- only for students participating in a Focus Project in the same semester.

Number of participants limited to 80.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1610 of 2416
151-0062-10L  Engineering Tool: Computer-Aided Design Methods
All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 25.

Abstract
Participants will learn about the Computer-Aided Design fundamentals and methods that are necessary to model complex technical products. The focus will be placed on feature-based and parametric modelling that is common to all modern CAD tools used in mechanical engineering design.

Objective
CAD knowledge and skills will be further developed to enable students to recognize both the advantages and the limitations of current Computer-Aided Design tools. Examples of how to build feature-based and parametric models including design automation will be given along with common pitfalls. After taking the course students should be able to independently create effective feature-based and parametric models of mechanical parts.

Content
1. CAD Methods and Feature-Based Design (2 afternoons):
   - CAD in the context of the design process
   - Feature types and their relation to mechanical design
   - Strategies for building feature-based assemblies
   - Integration of digital part libraries
   - Common issues and difficulties with feature interaction

2. CAD and Parametric Modeling (1 afternoon):
   - Designing and building parametric models
   - Design automation to create design variants
   - Common issues and difficulties with parametric modelling

Lecture notes
available on Moodle

151-0067-10L  Engineering Tool: Sketching and Visualization of Technical Concepts
All Engineering Tools courses are for MAVT Bachelor's degree students only.

Number of participants limited to 20.

Abstract
This course is offered by the Design and Technology Lab Zurich. Effective visualizations of ideas are essential to communicate technical concepts. This course focusses on the basics of a coherent draft design through forms of sketches using various simple techniques.

Objective
Mastering various simple techniques for the visualization of technical ideas.

Content
Basics in: Perspective, line drawing, proportions, implementation of the plan views of perspective

Literature
It requires no further books

Prerequisites / notice
Max 20 participants
Material: Paper and pens

151-0091-10L  Engineering Tool: Scientific Writing
All Engineering Tools courses are for MAVT Bachelor's degree students only.

Abstract
Participants acquire scientific writing basics as a core competency to communicate with different audiences. They apply important methods and tools to refine a scientific question, research and evaluate the necessary information, quote and paraphrase, and to plan the structure of their own text.

Objective
Students are able to
- derive and structure ideas for a text starting from a scientific question using simple techniques
- find literature sources, check their relevance and completeness, organize them with a suitable tool and cite correctly
- apply a reading technique for summarizing a text
- distinguish plagiarism, quotation and paraphrase in texts using the presented criteria and correctly cite or paraphrase external content
- use and cite information from the Internet correctly
- plan and structure specialized texts that refer to different target groups

Content
KURSPROGRAMM
  LEHRFORMEN
  - Inputs: Kurzvorträge und Selbstlernsequenzen
  - Uebungen: Hausaufgaben und während des Nachmittags selbständig in Moodle anhand von Fallstudien
  - Feedback und Diskussion: Lösungen der Studierenden werden gemeinsam mit den Dozierenden besprochen und diskutiert

Zu allen Inhaltsstücken gibt es Übungsteile in Moodle, für die ein Laptop mit funktionierendem Internetanschluss benötigt wird.

Prerequisites / notice
Computer for exercises during the afternoon

252-0864-00L  Engineering Tool: Parallel and Concurrent Programming in C++
All Engineering Tool courses are for MAVT-Bachelor students only.

Abstract
This course provides an introduction to parallel and concurrent programming, using C++. Basic challenges and concepts will be introduced and illustrated, and applied by students in small projects.

Objective
Students develop a basic understanding of the advantages and pitfalls of concurrency, and gain an overview of the field and its concepts. They learn how to solve small problems using concurrent programs.

Prerequisites / notice
The course can only be passed if the projects are successfully implemented and submitted. If no or insufficient solutions are submitted, the course is considered failed.

Workshop Training

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0003-00L</td>
<td>Workshop Training</td>
<td>O</td>
<td>5</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>
Abstract
The main objective of the minimum five-week internship is to provide Bachelor’s students with practical experience in producing components as well as knowledge and understanding about materials and their machining and finishing.

Objective
The main objective is to provide Bachelor’s students with practical experience in producing components as well as knowledge and understanding about materials and their machining and finishing.

Prerequisites / notice
The minimum duration of the workshop training is five weeks.

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**Laboratory Practice**

Students attend at least 10 Laboratory Practices during the 4th and 5th semester. 4 of them must be Physics laboratories. All laboratory works are graded “pass” or “fail”. After completion of 10 laboratory training units, 2 credit points will be issued.

Please register online at www.mavt.ethz.ch/praktika

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### Laboratory Practice

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-0029-10L</td>
<td>Laboratory Practice Enrollment is only possible under <a href="http://www.mavt.ethz.ch/praktika">www.mavt.ethz.ch/praktika</a>. No registration required via myStudies.</td>
<td>O</td>
<td>2 credits</td>
<td>4P</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Abstract
Selected laboratory experiments in physics, mechanical and process engineering. With the Laboratory Training held during the fourth and fifth semester, the students learn how to handle and apply measurement methods and devices. Students are offered a diversified choice of laboratory experiments at least ten of which must be completed. Four of the chosen experiments must be in physics.

Objective
With the Laboratory Training held during the fourth and fifth semester, the students learn how to handle and apply measurement methods and devices.

Prerequisites / notice
Der Link zur Website, welche alle Informationen für das Physikpraktikum bietet: https://ap.phys.ethz.ch

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### Bachelor's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
The Bachelor's Thesis is the culmination of the program. The thesis corresponds to a work load of 420 hours and can be done in part- or full-time.

Objective
The students develop, enhance and demonstrate their methodological abilities to independently tackle and solve a given research problem.

Content
The topics for the bachelor's thesis are published by the professorship or can be set in consultation between the professors and the students. Thesis projects in cooperation with the industry are also possible.

Prerequisites / notice
The Bachelor's Thesis can be only started when the First Year Examinations, the Additional First Year Courses, the Examination Block 1 and 2 are passed. It is insistently recommended for students to only begin the Bachelor's Thesis if 150 credit points have been achieved. The declaration of originality is an integral part of the Bachelor's Thesis

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### Bachelor's Thesis (Focus Specialization Management, Technology and Economics)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>

Abstract
The Bachelor's Thesis is the culmination of the program. The thesis corresponds to a work load of 420 hours and can be done in part- or full-time.

Objective
The students develop, enhance and demonstrate their methodological abilities to independently tackle and solve a given research problem.

Content
The topics for the bachelor's thesis are defined by the professorship or can be set in consultation between the professors and the students. The Bachelor's Thesis can be only started when the First Year Examinations, the Additional First Year Courses, the Examination Block 1 and 2 are passed. Exclusively D-MAVT students who have enrolled for the Focus Specialization Management, Technology and Economy are eligible for this type of Bachelor's Thesis. It is strongly recommended for students to only begin the Bachelor's Thesis if 150 credit points have been achieved. The declaration of originality is an integral part of the Bachelor's Thesis

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### Science in Perspective

**Science in Perspective**

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

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### Language Courses

see Science in Perspective: Language Courses ETH/UZH

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### Mechanical Engineering Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Letter</th>
<th>Description</th>
<th>Code</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>
### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
The courses listed in this category “Core Courses” are recommended. Alternative courses can be chosen in agreement with the tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0105-00L</td>
<td>Imaging in Fluid Dynamics</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>F. Coletti</td>
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<tr>
<td></td>
<td>Note: The previous course title until HS21 “Quantitative Flow Visualization”</td>
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<tr>
<td>Abstract</td>
<td>This is a laboratory-based course on imaging techniques for the measurement of fluid flow properties. Modern approaches are presented, including particle image velocimetry and particle tracking velocimetry, applied in various experimental facilities. Students obtain first-hand experience with such techniques in laboratory sessions, using high-speed/high-resolution cameras in wind/water tunnels. Understanding of hardware and software requirements to achieve desired spatio-temporal resolution. Ability to carry out imaging experiments in actual laboratory flows, and interpreting meaningfully the results. Knowledge of the working principles of modern flow imaging and velocimetry. Basics of optical diagnostics. Conception of laboratory flow experiment to be characterized by imaging, with focus on the spatial and temporal scales at play. Laboratory experiments including: - characterization of vortex shedding by wake visualization and liquid crystal thermography. - Eulerian flow field in turbulent flow by particle image velocimetry - Lagrangian flow field in turbulent flow by particle tracking velocimetry - fluid-structure interaction in wind tunnel by high-speed imaging.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Content</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts will be made available.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Fluid Dynamics, basic programming skills.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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<td></td>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td>Media and Digital Technologies</td>
<td>assessed</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Social Competencies</td>
<td>Communication</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Customer Orientation</td>
<td>not assessed</td>
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<td></td>
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<td>Leadership and Responsibility</td>
<td>assessed</td>
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<td></td>
<td></td>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
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<td></td>
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<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<td>Negotiation</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
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<td></td>
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<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
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<td>Integrity and Work Ethics</td>
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<td></td>
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<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
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</tr>
<tr>
<td>151-0107-20L</td>
<td>High Performance Computing for Science and Engineering (HPCSE) I</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering. With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind. The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.</td>
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<tr>
<td>Objective</td>
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<tr>
<td>Content</td>
<td>1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)</td>
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<td>2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)</td>
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<td>3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models</td>
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<td>4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis</td>
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<td>5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods</td>
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</tr>
<tr>
<td>Lecture notes</td>
<td><a href="https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/">https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/</a></td>
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<tr>
<td>Class notes</td>
<td>Handouts</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press</td>
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<tr>
<td></td>
<td>• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann</td>
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<tr>
<td></td>
<td>• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press</td>
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</tr>
</tbody>
</table>

Information on Data, Version and Pages
Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

151-0109-00L

Turbulent Flows

W 4 credits

2V+1U

P. Jenny

Abstract

Contents
- Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scalings. Homogeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows

Objective

Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling

Content
- Properties of laminar, transitional and turbulent flows.
- Origin and control of turbulence. Instability and transition.
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.
- Scalings, homogeneous isotropic turbulence, energy spectrum.
- Turbulent free shear flows. Jet, wake, mixing layer.
- Wall-bounded turbulent flows.
- Turbulent flow computation and modeling.

Lecture notes

Lecture notes are available

Literature


151-0125-00L

Hydrodynamics and Cavitation

W 4 credits

3G

O. Supponen

Abstract

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

Objective

The main learning objectives of this course are:
1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify hydrodynamic instabilities and discuss the stability region
3. Describe fragmentation of liquids
4. Explain tension, nucleation and phase-change in liquids.
5. Describe hydrodynamic cavitation and its consequences in physical terms.
6. Recognise experimental techniques and industrial and medical applications for cavitation.

Content

The course gives an overview on the following topics: hydrostatics, capillarity, hydrodynamic instabilities, fragmentation. Tension in liquids, phase change. Cavitation: single bubbles (nucleation, dynamics, collapse), cavitating flows (attached, cloud, vortex cavitation). Industrial applications and measurement techniques.

Lecture notes

Class notes and handouts

Literature

Literature will be provided in the course material.

Prerequisites / notice

Fluid dynamics I & II or equivalent

151-0163-00L

Nuclear Energy Conversion

W 4 credits

2V+1U

A. Manera

Abstract

Physical fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, conversion and breeding

Objective

Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.

Content

Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology.

Lecture notes

Hand-outs will be distributed. Additional literature and information on the website of the lab:

Literature


R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

151-0209-00L

Renewable Energy Technologies

W 4 credits

3G

A. Steinfeld, E. I. M. Casati

Abstract

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

Objective

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Prerequisite / notice

Lecture Notes containing copies of the presented slides.

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

151-0213-00L

Fluid Dynamics with the Lattice Boltzmann Method

W 4 credits

3G

I. Karlin

Abstract

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Objective

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
Content
The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   - Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory; Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   - Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   - Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   - Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   - Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   - Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   - Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   - Relativistic fluid dynamics; flows with phase transitions.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0215-00L Fundamentals of Acoustics W 4 credits 3G 4 credits N. Noiray, B. Van Damme

Abstract
This course provides an introduction to acoustics. It focusses on fundamental phenomena of airborne and structure-borne sound waves.

Objective
This course is proposed for Master and PhD students interested in getting knowledge in acoustics. Students will be able to understand, describe analytically and interpret sound generation, absorption and propagation.

Content
First, magnitudes characterizing sound propagation are reviewed and the constitutive equations for acoustics are derived. Then the different types of sources (monopole/dipole/quadrupole, punctual, non-compact) are introduced and linked to the noise generated by turbulent flows, coherent vortical structures or fluctuating heat release. The scattering of sound by rigid bodies is given in basic configurations. Analytical, experimental and numerical methods used to analyze sound in ducts and rooms are presented (Green functions, Galerkin expansions, Helmholtz solvers).

The second part covers elastic wave phenomena, such as dispersion and vibration modes, in infinite and finite structures.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available.
Selected original and review papers are provided for some of the lectures on advanced topics.
Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0216-00L Wind Energy W 4 credits 2V+1U 4 credits N. Chokani

Abstract
The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. These subjects are introduced through a discussion of the basic principles of wind energy generation and conversion, and a detailed description of the broad range of relevant technical, economic and environmental topics.

Objective
This mechanical engineering course focuses on the technical aspects of wind turbines; non-technical issues are not within the scope of this technically oriented course. On completion of this course, the student shall be able to conduct the preliminary aerodynamic and structural design of the wind turbine blades. The student shall also be more aware of the broad context of drivetrains, dynamics and control, electrical systems, and meteorology, relevant to all types of wind turbines.

Content
The global energy transition: Key performance indicators of sustainable energy systems; Optimization models; Heat integration and heat exchanger networks; Life-cycle assessment; Models for conversion, storage and transport technologies; Multi-energy systems; Design, operations and analysis of energy systems; Uncertainties in energy system modeling.

Lecture notes
Lecture slides and supplementary documentation will be available online. Reference to appropriate book chapters and scientific papers will be provided.

Autumn Semester 2022

Data: 01.11.2022 12:41
Basics of Air Transport (Aviation I)

151-0227-00L

**Abstract**
In general the course explains the main principles of air transportation and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation.

The program is taught in English and we provide 11 different experts/lecturers.

**Objective**
The goal is to understand and explain basics, principles and contexts of the broader air transport industry.

Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport.

**Content**
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

Preparation materials & slides are provided prior to each class

Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

The lecture is planned as class teaching.

**Literature**
Lecture notes

Preparation materials & slides are provided prior to each class

**Prerequisites / notice**
The lecture will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

**Fostered competencies**

**Method-specific Competencies**

- Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- Project Management
- Problem-solving

**Subject-specific Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Sensitivity to Diversity

- Adapting to and working effectively in diverse cultural, national and social settings
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**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

**Principles, Efficiency Optimization and Future Applications of IC Engines**

151-0251-00L

**Abstract**

**Objective**
The students get familiar with operating characteristics and efficiency maximization methods of IC engines for propulsion and decentralized electricity (and heat) generation. To this end, they learn about simulation methods and related experimental techniques for performance assessment in a combination of lectures and exercises.

**Content**
This lecture aims at introducing the students to the working principles and efficiency optimization methods for Internal Combustion (IC) engines which are expected to continue to play a very important role in transportation (long-haul heavy duty, marine) and decentralized combined heat and power generation. Following an overview of different applications and powertrains, the course will focus on the following topics: First, a generic overview of the history of IC-Engines is given, and the basic dimensions and specific engine-relevant terminology are introduced. Next, operating maps for different duty cycles are discussed, highlighting the benefits of individual powertrain configurations for different usage scenarios. The high-pressure thermodynamic process and combustion-induced heat release are analyzed in detail and the design of the combustion processes is discussed in view of further optimization of the energy conversion efficiency. The concept of boosting, its challenges and potential are also presented. In addition, field flow characteristics, convective and radiative heat transfer and combustion modes (Otto, Diesel and "multi-mode" cycles) will be discussed along with possible simulation methods. The course consists of lectures combined with exercises. In addition, several invited guest talks will be held by representatives from Swiss industrial companies active in this field. Provided the pandemic measures allow, visits to different engine test facilities are further envisioned.

**Literature**

**Prerequisites / notice**
This course provides background for the course 151-0254-00L “Environmental Aspects of Future Mobility” held in the Spring Semester, where the focus is on emission formation and minimization, exhaust gas after treatment systems and potentials of future synthetic/e-fuels in IC engines, all given in the broader context of a future mobility/transportation options (battery electric, hybrids, fuel cells etc.) and transformation pathways towards sustainability.

**Fostered competencies**

**Method-specific Competencies**

- Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

- Project Management
- Problem-solving

**Subject-specific Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Sensitivity to Diversity

- Adapting to and working effectively in diverse cultural, national and social settings
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**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

Aeroelasticity

151-0368-00L

**Abstract**
Introduction to the basics and methods of Aeroelasticity. An overview of the main static and dynamic phenomena arising from the interaction between structural and aerodynamic loads.

**Objective**
The course will provide a basic physical understanding of flow-structure interaction. You will get to know the most important phenomena in the static and dynamic aeroelasticity, as well as a presentation of the most relevant analytical and numerical prediction methods.
Introduction to steady and unsteady thin airfoil theory, extension to three dimension wing aerodynamics, strip theory, overview of numerical methods available (panel methods, CFD).

Presentation of steady aeroelasticity: equations of equilibrium for the typical section, aeroelastic deformation, effectiveness of the aeroelastic system, stability (definition), divergence condition, role played by a control surface, control effectiveness, sweep angle, aeroelastic tailoring of bending-torsion coupling. Ritz model to model beams, use of FEM, modal condensation, choice of generalized coordinates.

Numerical aeroelasticity (Test Cases extracted from the latest AIAA Aerelastic Prediction Workshops).

Aeroelasticity of modern aircraft: assessment of the effects induced by the control surfaces and control systems (Aeroservoelasticity), active controlled aircraft, flutter-suppression systems, certification (EASA, FAA).

Planning and execution of Wind Tunnel experiments with aeroelastic models. Live-execution of an experiment in the WT of the ETH.

Brief presentation of non-linear phenomena like Limit-Cycle Oscillations (LCO)

 Lecture notes
A script in English language is available.

Literature
Bispilnghoff Ashley, Aeroelasticity
Abbott, Theory of Wing sections,

151-0709-00L  Stochastic Methods for Engineers and Natural Scientists
W 4 credits 4G  D. W. Meyer-Massetti

Abstract
The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent and subsurface flows. Moreover, mathematical techniques are presented that are used to quantify uncertainty in various engineering applications.

Objective
By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover, you should be able to develop basic stochastic models of such systems.

Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
- Statistical tests for means and goodness-of-fit
All topics are illustrated with engineering applications.

Lecture notes
Detailed lecture notes will be provided.

Literature
Some textbooks related to the material covered in the course:

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

151-0851-00L  Robot Dynamics
W 4 credits 4G  M. Hutter, R. Siegwart

Abstract
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

Objective
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content
The course consists of three parts: First, we will refresh and deepen the student’s knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Prerequisites / notice
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

151-0917-00L  Mass Transfer
W 4 credits 2V+2U  S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.
Content

Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature


Prerequisites / notice

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology, and in energy-related applications.

151-0927-00L

Rate-Controlled Separations in Fine Chemistry

W 6 credits 3V+1U M. Mazzotti, V. Becattini

Abstract

The students are supposed to obtain detailed insight into the fundamentals of separation processes that are frequently applied in modern life science processes in particular, fine chemistry and biotechnology.

Objective

The class covers separation techniques that are central in the purification and downstream processing of chemicals and biopharmaceuticals. Examples from both areas illustrate the utility of the methods: 1) Adsorption and chromatography; 2) Membrane processes; 3) Crystallization and precipitation.

Lecture notes

Handouts during the class

Prerequisites / notice

Recommendations for text books will be covered in the class

Literature


Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies

Communication assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies

Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

151-0951-00L

Process Design and Safety

W 4 credits 2V+1U F. Trachsel, C. Hutter

Abstract

The lecture Process Design and Safety deals with the fundamentals of project management, scale-up, dimensioning and safety of chemical process equipment and plants.

Objective

The objective of the lecture is to expound the engineering design approach of important elements in chemical plant design.

Content

Fundamentals in Chemical engineering Design;
Project Management,
Cost estimate,
Materials and Corrosion,
Piping and Armatures,
Pumps,
Reactors and Scale-up,
Safety of chemical processes,
Patents

Lecture notes

The lecture slides will be distributed.

Literature


Prerequisites / notice

A 1-day excursion including a visit of a chemical plant will be part of the lecture.

151-1116-00L

Introduction to Aircraft and Car Aerodynamics

W 4 credits 3G M. Immer, F. Schröder

Abstract

Aircraft aerodynamics: Atmosphere; aerodynamic forces (lift, drag); thrust.

Objective

An introduction to the basic principles and interrelationships of aircraft and automotive aerodynamics.
To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components.
Illustration of the intrinsic problems and results using examples.
Using experimental and theoretical methods to illustrate possibilities and limits.

Content

Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force: profile, wings, Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.
Automobile aerodynamics: basic aerodynamic principles, examples of aerodynamics of cars, vehicle dynamics (resistance, driving forces, aerodynamic performance). Cars commercial vehicles, racing cars.

Lecture notes

Preparation materials & slides are provided prior to each class
Abstract

Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

Objective

The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

Content

Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro-codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FOSM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

Lecture notes

Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

Literature


S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

Prerequisites / notice

Basic course on probability theory and statistics

Abstract

Information Systems for Engineers

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality.
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).

Prerequisites / notice

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logic.

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python.

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lectures
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

Prerequisites 
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course provides an introduction to acoustics. It focuses on fundamental phenomena of airborne and structure-borne sound waves. The lecture combines theoretical principles with practical insights and interpretations.

Objective This course is proposed for Master and PhD students interested in getting knowledge in acoustics. Students will be able to understand, describe analytically and interpret sound generation, absorption and propagation.

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 1622 of 2416
First, magnitudes characterizing sound propagation are reviewed and the constitutive equations for acoustics are derived. Then the different types of sources (monopole/dipole/quadrupole, punctual, non-compact) are introduced and linked to the noise generated by turbulent flows, coherent vortical structures or fluctuating heat release. The scattering of sound by rigid bodies is given in basic configurations. Analytical, experimental and numerical methods used to analyze sound in ducts and rooms are presented (Green functions, Galerkin expansions, Helmholtz solvers).

The second part covers elastic wave phenomena, such as dispersion and vibration modes, in infinite and finite structures.

### 151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

**Abstract**
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

**Objective**
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

**Content**
- Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

**Didactical concept:**
The course consists of lectures and exercises.

**Literature**
The handout is available in German and English.

**Prerequisites / notice**
Prerequisites:
- "Visualization, Simulation and Interaction - Virtual Reality I" is recommended, but not mandatory.

### 151-0353-00L Mechanics of Composite Materials

**Abstract**
Focus is on laminated fibre reinforced polymer composites. The course treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

**Objective**
To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

**Content**
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Thin ply composite shells & effects of material non-linearity

**Lecture notes**
Script, handouts, exercises and additional material are available in PDF-format on moodle page of the lecture.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Competency Area</th>
<th>Assessed</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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### 151-0368-00L Aeroelasticity

**Abstract**
Introduction to the basics and methods of Aeroelasticity. An overview of the main static and dynamic phenomena arising from the interaction between structural and aerodynamic loads.
Objective
The course will provide a basic physical understanding of flow-structure interaction. You will get to know the most important phenomena in the static and dynamic aeroelasticity, as well as a presentation of the most relevant analytical and numerical prediction methods.

Introduction to steady and unsteady thin airfoil theory, extension to three dimension wing aerodynamics, strip theory, overview of numerical methods available (panel methods, CFD).

Introduction to unsteady aerodynamics (theory): Theodorsen and Wagner functions. Unsteady aerodynamics observed from numerical experiments (CFD). Generation of simplified mathematical models.

Presentation of steady aeroelasticity: equations of equilibrium for the typical section, aeroelastic deformation, effectiveness of the aeroelastic system, stability (definition), divergence condition, role played by a control surface, control effectiveness, sweep angle, aeroelastic tailoring of bending-torsion coupling. Ritz model to model beams, use of FEM, modal condensation, choice of generalized coordinates.


Numerical aeroelasticity (Test Cases extracted from the latest AIAA Aeroelastic Prediction Workshops).

Aeroelasticity of modern aircraft: assessment of the effects induced by the control surfaces and control systems (Aeroservoelasticity), active controlled aircraft, flutter-suppression systems, certification (EASA, FAA).

Planning and execution of Wind Tunnel experiments with aeroelastic models. Live-execution of an experiment in the WT of the ETH.

Brief presentation of non-linear phenomena like Limit-Cycle Oscillations (LCO)

151-0509-00L
Acoustics in Fluid Media: From Robotics to Additive Manufacturing

W 4 credits 3G D. Ahmed

Note: The previous course title until HS21 "Microscale Acoustofluidics"

Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

Lecture notes

Literature

151-0524-00L
Continuum Mechanics I

W 4 credits 2V+1U A. E. Ehret

Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.

Content
Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, Plasticity, Viscoplasticity, Examples of engineering applications, Comparison with experiments

Lecture notes
yes

151-0525-00L
Dynamic Behavior of Materials

W 4 credits 2V+2U T. Tancogne-Dejean, C. Roth

Abstract
Lectures and computer labs concerned with the modeling of the deformation response and failure of engineering materials (metals, polymers and composites) subject to extreme loadings during manufacturing, crash, impact and blast events.

Objective
Students will learn to apply, understand and develop computational models of a large spectrum of engineering materials to predict their dynamic deformation response and failure in finite element simulations. Students will become familiar with important dynamic testing techniques to identify material model parameters from experiments. The ultimate goal is to provide the students with the knowledge and skills required to engineer modern multi-material solutions for high performance structures in automotive, aerospace and naval engineering.

Content
Topics include temperature and strain rate dependent elasto-plasticity, dynamic brittle and ductile fracture; impulse transfer, impact and wave propagation in solids; computational aspects of material model implementation; simulation of dynamic failure of structures;

Lecture notes
Slides of the lectures, relevant journal papers and user manuals will be provided.

Literature
Various books will be recommended pertaining to the topics covered.
Prerequisites / notice
Course in continuum mechanics (mandatory), finite element method (recommended)

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving assessed
Project Management assessed

Social Competencies
Communication not assessed

Personal Competencies
Creative Thinking not assessed
Critical Thinking not assessed

151-0529-00L Computational Mechanics II: Nonlinear FEA W 4 credits 2V+2U L. De Lorenzis

Abstract
The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

Objective
To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

Content
1. Introduction: various sources of nonlinearities and implications for FEA.

Lecture notes
Lecture notes will be provided. However, students are encouraged to take their own notes.

Prerequisites / notice
Mechanics 1, 2, Dynamics, Continuum Mechanics I and Introduction to FEA. Ideally also Continuum Mechanics II.

151-0532-00L Nonlinear Dynamics and Chaos I W 4 credits 2V+2U G. Haller

Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

151-0535-00L Optical Methods in Experimental Mechanics and Processing Technology W 4 credits 3G

Abstract
The lecture introduces optical methods to assess engineering structures and material parameters, and to validate numerical simulations. Their strengths and limitations in industrial applications are discussed. Selected fabrication technologies are introduced, together with their optical methods of quality control. The lecture includes two afternoons of hands-on experience at Empa in Dübendorf.

Objective
The students are able to describe the process of imaging and image acquisition. They know how to design simple experiments based on optical methods. They understand the working principle of the optical techniques. Specifically, they can explain how a mechanical measurand such as shape, deformation and strain is transformed into an optical signal such as interference, a change of the polarization state or a change of surface temperature. They know the main application field of the individual techniques. They are able to choose the most appropriate technique for solving a specific measurement task and to estimate its expected resolution. In addition, they understand the basics of processing technologies from the clean room or from 3D printing and how they can assess the quality of the structures. Through the hands-on experiences the students gain a deeper and sustained understanding by applying the theoretical foundations to tangible measurement tasks.
After an introduction into optics and image acquisition, the lecture explains how to transform mechanical quantities such as shape, deformation, strain or stress into an image content. The measurement techniques make use of a variety of principles such as

- Triangulation
- Interference
- Diffraction
- Birefringence
- Infrared radiation

The techniques rely on cameras, most notably semiconductor sensors as well as micro-bolometers, and make use of incoherent white light and coherent light sources such as halogen lamps and lasers, respectively. The topics of the lecture include:

- Optics and imaging
- Digital Image Correlation in 2D and 3D
- Fringe Projection and structured light techniques
- Diffraction and holography
- Speckle pattern interferometry
- Terahertz (THz) techniques
- Thin film processes and 3D printing
- Photelasticity and ellipsometry
- Thermoelastic Stress Analysis
- Validation of numerical models

We show how the methods are applied to microsystems as well as large engineering structures. In addition, time-resolved measurements in the context of modal analysis and dynamic events are explained.

The lecture includes two afternoons at Empa, where the students will gain first-hand experience with optical methods in the laboratory. Depending on availability of the equipment and the interest of the students, these hands-on classes may include e.g. Digital Image Correlation, speckle pattern interferometry, THz holography, Thermal Stress Analysis, ellipsometry and fringe projection.

Lecture notes
Copies of the presented slides will be made available in advance through ILIAS. These slide copies allow the student to add own notes and explanations given during the lecture. We will strive to provide summary scripts for each lesson. Each lecture includes a set of exercises. Standard solutions for the exercises will be posted with a time lag.

Finally, you will be invited to a private blog which shall stimulate the discussion of the lecture content and the exercises.

Literature
A good overview on the optical methods is presented in the following text books:

ISBN 978-1-4665-7359-8

2012, Wiley-VCH, Berlin
ISBN 978-3-527-41111-5

Prerequisites / notice
Basic knowledge of optics and interferometry as taught in basic physics courses are advantageous. We encourage the audience to share their specific questions and measurement tasks.

151-0550-00L Adaptive Materials for Structural Applications W 4 credits 3G A. Bergamini

Abstract
Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated, also with laboratory experiments where possible.

Objective
The study of adaptive materials covers topics that range from chemistry to theoretical mechanics.

The aim of this course is to convey knowledge about adaptive materials, their properties and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

Content
This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions. Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion
Thermo-mechanical coupling: Shape memory alloys / polymers
Electromechanical coupling(1): DEA, EBL, electrorheological fluids
Shape control / morphing: Use, requirements, challenges
Morphing applications of variable stiffness structures: Lab work
Electromechanical coupling (2): Piezoelectric, electrostrictive effect
Vibration Reduction: Measurement, passive, semi-active (active) damping methods
Vibration reduction applications of piezoelectric materials: Lab work
Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials
Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...
Abstract

Objective
Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.

Content
This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.

Lecture notes
The handouts in English will be available in digital form.

Literature
A list of references is included in the handouts.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking not assessed
Self-direction and Self-management not assessed

Skills for Creativity and Innovation

Abstract
This lecture aims to enhance the knowledge and competency of students regarding their innovation capability. An overview on prerequisites of and different skills for creativity and innovation in individual & team settings is given. The focus of this lecture is clearly on building competencies - not just acquiring knowledge.

Objective
- Basic knowledge about creativity and skills
- Knowledge about individual prerequisites for creativity
- Development of individual skills for creativity
- Knowledge about teams
- Development of team-oriented skills for creativity
- Knowledge and know-how about transfer to idea generation teams

Content
Basic knowledge about creativity and skills:
- Introduction into creativity & innovation: definitions and models

Knowledge about individual prerequisites for creativity:
- Personality, motivation, intelligence

Development of individual skills for creativity:
- Focus on creativity as problem analysis & solving
- Individual skills in theoretical models
- Individual competencies: exercises and reflection

Knowledge about teams:
- Definitions and models
- Roles in innovation processes

Development of team-oriented skills for creativity:
- Idea generation and development in teams
- Cooperation & communication in innovation teams

Knowledge and know-how about transfer to idea generation teams:
- Self-reflection & development planning
- Methods of knowledge transfer

Lecture notes
Slides, script and other documents will be distributed via moodle.ethz.ch
(access only for students registered to this course)

Literature
As well as material handed out in the lecture

Operational Simulation of Production Lines

Abstract
The students learn the application of the event-driven and computer-based simulation for layout and operational improvement of production facilities by means of practical examples. The simulation provides an essential basis for digital twins in Industry 4.0.
Objective
The students learn the right use of (Who? When? How?) of the event-driven and computer-based simulation in the illustration of the operating procedures and the production facilities. The simulation is an important basis for creating a digital twin in the context of Industry 4.0.

Content
- Application and application areas of the event-driven simulation
- Simulation in the context of Industry 4.0 (digital twin)
- Exemplary application of a software tool (Technomatix-Simulation-Software)
- Internal organisation and functionality of simulation tools
- Procedure for application: optimizing, experimental design planning, analysis, data preparation
- Controlling philosophies, emergency concepts, production in sequence, line production, rescheduling
- Application on the facilities projecting

The knowledge is enhanced by practice-oriented exercises and an excursion. A guest speaker will present a practical example.

Lecture notes
Will be sent by email before the lecture (pdf).

Literature
A bibliography will be given during the lectures.

Prerequisites / notice
Recommended for all Bachelor-Students in the 5th semester and Master-Students in the 7th semester (MAVT, MTEC).

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Cooperation and Teamwork
- Customer Orientation
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

<table>
<thead>
<tr>
<th>Code</th>
<th>Module Title</th>
<th>W</th>
<th>2V+2U</th>
<th>4 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0705-00L</td>
<td>Manufacturing I</td>
<td>W</td>
<td>4 credits</td>
<td>2V+2U</td>
</tr>
<tr>
<td>Objective</td>
<td>Deepened discussion on the machining processes and their optimisation. Outlook on additional areas such as NC-Technique, dynamics of processes and machines, chatter as well as process monitoring.</td>
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<tr>
<td>Content</td>
<td>Deepened insight in the machining processes and their optimisation, chip removal by undefined cutting edge such as grinding, honing and tapping, machining processes without cutting edges such as EDM, ECM, outlook on additional areas as NC-technique, machine- and process dynamics including chatter and process monitoring</td>
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<tr>
<td>Lecture notes</td>
<td>Yes</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Recommendation: Lecture 151-0700-00L Manufacturing elective course in the 4th semester. Language: Help for English speaking students on request as well as english translations of the slides shown.</td>
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<thead>
<tr>
<th>Code</th>
<th>Module Title</th>
<th>W</th>
<th>2V+1U</th>
<th>4 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0717-00L</td>
<td>Mechanical Production: Assembly, Joining and Coating Technology</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
</tr>
<tr>
<td>Abstract</td>
<td>Understanding of the complexity of the assembly process as well as its meaning as success and cost factor. The assembly with the different aspects of adding, moving, adjusting, controlling parts etc. Adding techniques; solvable and unsolvable connections. Assembly plants. Coating techniques and their tasks, in particular corrosion protection.</td>
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<tr>
<td>Objective</td>
<td>To understand assembly in its full complexity and its paramount importance regarding cost and financial success. An introduction into a choice of selected joining and coating techniques.</td>
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<tr>
<td>Content</td>
<td>Assembly as combination of several classes of action like, e.g., joining, handling, fine adjustments, etc. Techniques for joining objects temporarily or permanently. Assembly systems. Coating processes and their specific applications, with particular emphasis on corrosion protection.</td>
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<tr>
<td>Lecture notes</td>
<td>Yes</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Recommended to the focus production engineering. Majority of lecturers from the industry.</td>
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<tr>
<th>Code</th>
<th>Module Title</th>
<th>W</th>
<th>2V+1U</th>
<th>4 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0719-00L</td>
<td>Quality of Machine Tools - Dynamics and Metrology at Micro and Submicro Level</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course &quot;Machine tool metrology&quot; deals with the principal design of machine tools, their spindles and linear axes, with possible geometric, kinematic, thermal and dynamic errors of machine tools and testing these errors, with the influence of errors on the workpiece (error budgeting), with testing of drives and numerical control, as well as with checking the machine tool capability.</td>
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<tr>
<td>Objective</td>
<td>Knowledge of principal design of machine tools, errors of linear and rotational axes and of machine tools, influence of errors on the workpiece (error budgeting), dynamics of mechanical systems, measurement data acquisition / digital signal analysis, experimental modal analysis, geometric, kinematic, thermal, dynamic testing of machine tools, test uncertainty, machine tool capability.</td>
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</tbody>
</table>
Creative Thinking

Control (PLC, NC), closed loop control, processing of geometrical data, main drives, noise emission, flexibility, rationalization and assessed

K. Wegener, S. Weikert

Deeper competence for evaluation and development of production machines, sensitization for unconventional kinematics with their assessed

Production Machines II, R.

Knowledge about the value added process sequence for electronics manufacturing, planning of electric and electronic product as well as assessed

Definitions and methodes what leadership is about based on real industrial examples. Levels of Leadership. Conflicts, challenges and risks assessed

Yes, always after lecture via mail.

Concepts and Theories

Exciting Leadership in a Thrilling Real Business assessed

Production Machines II

Productive Machines II W 4 credits 2V+1U K. Wegener, S. Weikert

Abstract

Control, closed loop control, processing of geometrical data, main drives, noise, flexibility, rationalization and automation, modern machine concepts, thermal and dynamic behavior

Objective

Deeper competence for evaluation and development of production machines, sensitization for unconventional kinematics with their advantages and drawbacks.

Content

Control (PLC, NC), closed loop control, processing of geometrical data, main drives, noise emission, flexibility, rationalization and automation, modern machine concepts like high speed machines, alternative kinematics, ultraprecision machines, thermal and dynamic behavior of machine tools, flexibility, rationalization and automation, practical case studies

Lecture notes

Documents are provided during the course. English handouts available on request.

Prerequisites / notice

Exercises in the laboratories and with the machine tools of the institute for machine tools and manufacturing (IWF) provide the practical background for this course.

Manufacturing of Electronic Devices

Manufacturing of Electronic Devices W 4 credits 3G A. Kunz, R.-D. Moryson, F. Reichert

Abstract

The lecture follows the value added process sequence of electric and electronic components. It contains: Development of electric and electronic circuits, design of electronic circuits on printed circuit boards as well as in hybrid technology, integrated test technology, planning of production lines, production of highly integrated electrically on a wafer as well as recycling.

Objective

Knowledge about the value added process sequence for electronics manufacturing, planning of electric and electronic product as well as their production, planning of production lines, value added process sequence for photovoltaics.

Content

Nothing works without electronics! Typical products in mechanical engineering such as machine tools, as well as any kind of vehicle contain a significant amount of electric or electronic components of more than 60%. Thus, it is important to master the value added process sequence for electric and electronic components.

The lecture starts with a brief introduction of electronic components and the planning of integrated circuits. Next, an overview will be provided about electronic functional units assembled from these electronic components, on printed circuit boards as well as in hybrid technology. Value added process steps are shown as well as their quality check and their combination for planning a complete manufacturing line. The lecture further describes the manufacturing of integrated circuits, starting from the wafer via the structuring and bonding to the packaging. As an example, the manufacturing of micro-electromechanic and electro-optical systems and actuators is described. Due to similar processes in the electronic production, the value added process sequence for photovoltaics will described too.

The lecture concludes with an excursion to a large manufacturing company. Here, students can the see the application and realization of the manufacturing of electric and electronic devices.

Lecture notes

Lecture notes are handed out during the individual lessons.

Prerequisites / notice

The lecture is partly given by experts from industry.

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed

Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed

Decision-making assessed

Problem-solving assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation assessed

Personal Competencies

Creative Thinking assessed

Critical Thinking assessed

Critical Thinking

Customer Orientation

Cooperation and Teamwork

Personal Competencies

Exciting Leadership in a Thrilling Real Business

Exciting Leadership in a Thrilling Real Business World W 4 credits 3G A. Halbleib

Abstract

What is leadership in a real world? What are the preconditions of personal leadership? What is the differences between Leadership and Management? What is the price to be payed to be a Leader? What are the core competences of a Leader? How to become an inspiring Leader? How to experience exciting leadership in a thrilled real business world.

Objective

The objective of this course is to understand the impact of Leadership and to learn based on longterm international leadership experiences very practicable competences and skills needed to be a leader.

Content

Definitions and methods what leadership is about based on real industrial examples. Levels of Leadership. Conflicts, challenges and risks of Leaders. Competences of a leader such as: decision making processes, communication, emotional intelligence, change processes and understanding of people behaviours.

Lecture notes

Yes, always after lecture via mail.

Literature

Not mandatory, but to be recommended: "The Effective Executive" from Peter Drucker, Verlag Vahlen; ISBN 978 3 8006 46715 from 2014.
### 151-0727-00L Colloquium on Manufacturing Technology

**Abstract**
Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures, by the majority by experts from the industry. The students prepare a summary of the lectures given and prepare themselves on the basis of these lectures and own information search.

**Objective**
Continuous further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

**Content**
Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

**Lecture notes**
- No Script
- Students must have participated and passed the courses Manufacturing, Production Machines I and Forming Technology III - Forming Processes.
- Further training with specialized lectures and large participation from the industry.

**Language:** Help for English speaking students on request.

### 151-0729-00L Welding Technology

**Abstract**
The course provides a survey over the mostly used welding technologies and a basic metallurgical understanding for planning and realization of welded joints.

**Objective**
The students will gain the competence and understanding to select welding processes properly, to specify the seam preparation and to predict the achievable welding results.

**Content**
The course presents in some detail the welding processes gas welding, TIG, MIG/MAG, Fillerwire welding arc welding and laser welding. After the presentation of the basics of welding the special properties of the different process technologies are explained and the energy sources and the interaction between the process energy and the material discussed. The metallurgical basics to answer material problems presented. From this process parameters can then be derived, to achieve the desired seam qualities.

**Lecture notes**
- The course is oriented towards the requirements of IIW / SVS and is part of the program to attain the international welding engineer diploma (IWE).
- The course will be distributed accompanying the course progress together with the lecture slides.

**Language:**

### 151-0733-00L Basics and Processes of Metal Forming

**Abstract**
The lecture teaches on the basic knowledge of major processes in sheet metal, tube and bulk metal forming technologies. In particular it focuses on fundamental computation methods, which allow a fast assessment of process behaviour and a rough layout. Process-specific states of stress and deformation are analysed and process limits are identified.

**Objective**

**Content**
The study of metal working processes: sheet metal forming, folding die cutting, cold bulk metal forming, ro extrusion, plunging, open die forging, drop forging, milling; active principle; elementary methods to estimate stress and strain; fundamentals of process design; manufacturing limits and machining accuracy; tools and operation; machinery and machine usage.

**Lecture notes**

### 151-0741-00L Sustainable Materials

**Abstract**
The lecture addresses the issue of sustainability in manufacturing, focusing on materials. The most used materials, their production and transformation into a product are analysed in terms of energy consumption and emissions. Emphasis is then placed on alternative design strategies which reduce the use of materials and innovative processes which lower energy consumption and emissions.

**Objective**
After this lecture students will be able to:
- Develop a critical thinking of published sustainability data and facts
- Explain where the materials that we use come from, what emissions arise from the different steps of raw material production and product manufacturing
- Determine where significant changes can be brought
- Develop feasible solutions towards a more sustainable use of materials
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's

In this course, the students will learn:

- Fatigue and Fracture in Materials and Structures

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content

- Introduction : what is sustainability, which industrial sectors are responsible for the most CO2 (and other) emissions
- The "real" numbers: where to find reliable data and how one can play with the figures
- Basics of life cycle analysis
- CO2 and other emissions
- The most used materials
  - The 5 most used materials today, their key properties and what they are used for
  - Evolution of production, consumption and resources
- Production, recyclability and new processing routes for Al and steel
- Use less material by design
- Re-use of materials & prolonging products life
- Production of cement, new developments & alternatives
- Presentation of students' projects

151-0833-00L

Applied Finite Element Analysis

W  4 credits 2V+2U B. Berisha, D. Mohr

Abstract

Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-METHOD (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

Objective

The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-METHOD based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the nonlinear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

Content

- introduction into FEM
- Fundamentals of continuum mechanics to characterize large plastic deformations
- Elasto-plastic material models
- Lagrange and Euler approaches
- FEM implementation of constitutive equations
- Element formulations
- Implicit and explicit FEM methods
- FEM formulations of coupled thermo-mechanical problems
- Modeling of tool contact and the influence of friction
- Solvers and convergence
- Instability problems

Lecture notes

Lecture slides

Literature


151-0917-00L

Mass Transfer

W  4 credits 2V+2U S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Abstract

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content

Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature


Prerequisites / notice

Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

101-0121-00L

Fatigue and Fracture in Materials and Structures

W  4 credits 3G A. Taras

Abstract

The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

Objective

In this course, the students will learn:

- Linear elastic and elastic-plastic fracture mechanics.
- Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
- Laboratory fatigue and fracture tests on details with cracks.
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- ELastic fracture mechanics (LEFM): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and "Laboratory Competition". The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Compare the experimental results with their own calculations (from the fracture theories).
- "Laboratory Competition" at Empa: the students with the closest predictions will win the "Empa Laboratory Competition" and will be awarded by a prize.

Lecture notes
Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Literature

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.
Objective

- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content

EST I (Herbstsemester) - Begriffen, Grundlagen, Merkmale

1 Einführung:
   1.1 Geschichte und Struktur des Bahnsystems
   1.2 Fahrdynamik

2 Vollbahnfahrzeuge:
   2.3 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
   2.2 Bremsen
   2.3 Traktionsantriebsysteme
   2.4 Hilfsbetriebe und Komfortanlagen
   2.5 Steuerung und Regelung

3 Infrastruktur:
   3.1 Fahrdweg
   3.2 Bahnstromversorgung
   3.3 Sicherungsanlagen

4 Betrieb:
   4.1 Interoperabilität, Normen und Zulassung
   4.2 RAMS, LCC
   4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastvorträge

Geplante Auskünfte:
Betriebszentrale SBB, Zürich Flughafen
Reparatur und Unterhalt, SBB Zürich Altstetten
Fahrzeugversorgung, Stadtler Bussanng

Lecture notes

Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice

Dozent: Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

EST I (Herbstsemester) kann als in sich geschlossene einsemestrige Vorlesung besucht werden. EST II (Frühjahrssemester) dient der weiteren Vertiefung der Fahrzeugtechnik und der Integration in die Bahninfrastruktur.

Fostered competencies

<table>
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<tr>
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252-0535-00L Advanced Machine Learning W 10 credits 3V+2U+4A J. M. Buhmann, C. Cotrini Jimenez

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensible to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory

- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks

- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.


Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

252-0543-01L Computer Graphics 8 credits 3V+2U+2A M. Gross, M. Papas

Abstract
This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

Objective
At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students’ curiosity to explore the field of computer graphics in subsequent courses or on their own.

Content
This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.

Lecture notes
no

Literature
Books:
- High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
- Multiple view geometry in computer vision
- Physically Based Rendering: From Theory to Implementation

Prerequisites /
Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.

The programming assignments will be in C++. This will not be taught in the class.

252-0834-00L Information Systems for Engineers 4 credits 2V+1U G. Fourny

Abstract
This course provides the basics of relational databases from the perspective of the user.

Objective
We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.

2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).

3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.

4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality

5. Explain what bad design is and why it matters.

6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".

7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.

8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.

9. Explain what data independence is all about and didn't age a bit since the 1970s.

10. Explain, in the big picture, how a relational database is physically implemented.

11. Know and deal with the natural syntax for relational data, CSV.

12. Explain the data cube model including slicing and dicing.

13. Store data cubes in a relational database.

14. Map cube queries to SQL.

15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.
Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

351-0555-00L Open- and User Innovation

Abstract
This course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.

Objective
The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active lass participation is required.

Content
This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

Lecture notes
The slides of the lectures are made available and updated continuously through the SMI website:

Literature
Relevant literature for the course includes slides and reading assignments. Papers will be made available through a corresponding Moodle group.

363-0445-00L Production and Operations Management

Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.
Objective

This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:
1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Content

The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM, Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Literature

Suggested literature is provided in the syllabus.

Fostered competencies

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<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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363-0541-00L Systems Dynamics and Complexity W 3 credits 3G F. Schweitzer

Abstract

Finding solutions: what is complexity, problem solving cycle.
Implementing solutions: project management, critical path method, quality control feedback loop.
Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

Objective

A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1636 of 2416
Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

W 3 credits 2V R. Riener, O. Lambercy

Abstract
Rehabilitation Engineering II is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

Objective
Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

Content
Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
Brain stimulation and recording
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see "Prerequisites").

Lecture notes
The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.
Topics covered in this course include:

- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to address MAM challenges (including, but not limited to, thermal, fluid, mechanical, and microstructural simulations). The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges. The students will also practice applying the learned models to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to solving linear programs and basic combinatorial optimization problems. Students will also practice applying the learned models to solving linear programs and basic combinatorial optimization problems.

Selected Journal Articles and Web Links:


Prerequisites / notice

Target Group: Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

401-0647-00L Introduction to Mathematical Optimization W 5 credits 2V+1U D. Adjiaashvili

Prerequisites / notice

The course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advanced course covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

151-0544-00L Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis W 4 credits 3G E. Hosseini

Abstract

An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective

The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.
Content

- Introduction to MAM (concept, application examples, pros & cons),
- Powder-bed and powder-blown metal additive manufacturing,
- Thermo-fluid analysis of additive manufacturing,
- Continuum-based thermal modelling and experimental validation techniques,
- Residual stress and distortion simulation and verification methods,
- Microstructural simulation (basics, analytical, kinetic Monte Carlo, cellular automata, phase-field),
- Mechanical property prediction for MAM,
- Microstructure and mechanical response of MAM material (steels, Ti6Al4V, Inconel, Al alloys),
- Design for additive manufacturing

- Artificial intelligence for AM

Exercise sessions use COMSOL, ANSYS, ABAQUS packages for analysis of MAM process. Detailed video instructions will be provided to enable students to set up their own simulations. COMSOL, ANSYS and ABAQUS agreed to support the course by providing licenses for the course attendees and therefore the students can install the packages on their own systems.

Lecture notes

Handouts of the presented slides.

Literature

No textbook is available for the course (unfortunately), since it is a dynamic and relatively new topic. In addition to the material presented in the course slides, suggestions/recommendations for additional literature/publications will be given (for each individual topic).

Prerequisites / notice

A basic knowledge of mechanical analysis, metallurgy, thermodynamics is recommended.

Fostered competencies

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Robots, Systems and Control

The courses listed in this category "Core Courses" are recommended. Alternative courses can be chosen in agreement with the tutor.

Number Title Type ECTS Hours Lecturers

151-0107-20L High Performance Computing for Science and Engineering (HPCSE) W 4 credits 4G S. M. Martin, J. H. Walther

Abstract

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

Objective

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content

1. Hardware and Architecture: Moore's Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes

https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/
Class notes, handouts

Literature

- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

151-0325-00L Planning and Decision Making for Autonomous Robots W 4 credits 2V+1U E. Frazzoli

Abstract

Planning safe and efficient motions for robots in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and ethical/regulatory aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

Objective

The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

Content


Lecture notes

Course notes and other education material will be provided for free in an electronic form.

Literature

There is no required textbook, but an excellent reference is Steve Lalaville's book on "Planning Algorithms."

Prerequisites / notice

Students should have taken basic courses in optimization, control systems, probability theory, and should be familiar with modern programming languages and practices (e.g., Python, and/or C/C++). Previous exposure to robotic systems is a definite advantage.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Course Code</td>
<td>Course Title</td>
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<tr>
<td>151-0371-00L</td>
<td>Advanced Model Predictive Control</td>
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<td>Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.</td>
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<td>Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.</td>
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<td>Topics include:</td>
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<td>- Nominal MPC for uncertain systems (nominal robustness)</td>
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<td>- Robust MPC</td>
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<td>- Stochastic MPC</td>
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<td>- Review of regression methods</td>
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<td>- Set-membership Identification and robust data-driven MPC</td>
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<td>- Bayesian regression and stochastic data-driven MPC</td>
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<td>- MPC as safety filter for reinforcement learning</td>
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<td>Lecture notes will be provided.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td>Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended.</td>
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<td></td>
<td>Background in linear algebra and stochastic systems recommended.</td>
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</tbody>
</table>

| 151-0532-00L | Nonlinear Dynamics and Chaos I                         | 4         | 2V+2U     | G. Haller                           |
|              | Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics. |
|              | This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year. |
|              | (1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data. |
|              | (2) Near equilibrium dynamics: Linear and Lyapunov stability |
|              | (3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations |
|              | (4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles. |
|              | (5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance |
|              | Lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture. |
|              | - Prerequisites: Analysis, linear algebra and a basic course in differential equations. |
|              | - Exam: two-hour written exam in English. |
|              | - Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates. |

| 151-0563-01L | Dynamic Programming and Optimal Control                | 4         | 2V+1U     | R. D’Andrea                         |
|              | Introduction to Dynamic Programming and Optimal Control. |
|              | Covers the fundamental concepts of Dynamic Programming & Optimal Control. |
|              | Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control. |
|              | Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra. |

| 151-0567-00L | Engine Systems                                          | 4         | 3G        | C. Onder                            |
|              | Introduction to current and future engine systems and their control systems |
|              | Introduction to methods of control and optimization of dynamical systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantitative descriptions. |
|              | Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.). |
|              | Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions. |
|              | Lectures notes will be posted electronically. Students should not rely on these but prepare their own notes during the lecture. |
|              | - Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups |

| 151-0569-00L | Vehicle Propulsion Systems                             | 4         | 3G        | C. Onder, P. Elbert                 |
|              | Introduction to current and future propulsion systems and the electronic control of their longitudinal behavior |
|              | Introduction to methods of system optimization and controller design for vehicles. Understanding the structure and working principles of conventional and new propulsion systems. Quantitative descriptions of propulsion systems. |
|              | Understanding of physical phenomena and mathematical models of components and subsystems (manual, automatic and continuously variable transmissions, energy storage systems, electric drive trains, batteries, hybrid systems, fuel cells, road/wheel interaction, automatic braking systems, etc.). |
|              | Presentation of mathematical methods, CAE tools and case studies for the model-based design and control of propulsion systems with the goal of minimizing fuel consumption and emissions. |
|              | Lectures notes will be posted electronically. Students should not rely on these but prepare their own notes during the lecture. |
|              | - Vehicle Propulsion Systems -- Introduction to Modeling and Optimization |
|              | ISBN: 978-3-642-35912-5 |

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1640 of 2416
**151-0573-00L System Modeling**

**W 4 credits 2V+1U**

**L. Guzzella**

**Abstract**
Introduction to system modeling for control. Generic modeling approaches based on first principles, Lagrangian formalism, energy approaches and experimental data. Model parametrization and parameter estimation. Basic analysis of linear and nonlinear systems.

**Objective**
Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.

**Content**
This class introduces generic system-modeling approaches for control-oriented models based on first principles and experimental data. The class will span numerous examples related to mechatronic, thermodynamic, chemistry, fluid dynamic, energy, and process engineering systems. Model scaling, linearization, order reduction, and balancing. Parameter estimation with least-squares methods. Various case studies: loud-speaker, turbines, water-propelled rocket, geostationary satellites, etc. The exercises address practical examples.

**Lecture notes**
The handouts in English will be available in digital form.

**Literature**
A list of references is included in the handouts.

**Fostered competencies**
- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: assessed
  - Project Management: not assessed
- Social Competencies
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed
- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: not assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

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**151-0593-00L Embedded Control Systems**

**W 4 credits 6G**

**C. Onder, M. Schmid Daners**

**Abstract**
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

**Objective**
Familiarize students with main architectural principles and concepts of embedded control systems.

**Content**
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

**Lecture notes**
Lecture notes, lab instructions, supplemental material

**Prerequisites / notice**
Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

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**151-0601-00L Theory of Robotics and Mechatronics**

**W 4 credits 3G**

**to be announced**

**Abstract**
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Objective**
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Content**
An introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

**Lecture notes**
available.

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**151-0604-00L Microrobotics**

**W 4 credits 3G**

**B. Nelson**

**Abstract**
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

**Objective**
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.
For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind HoloLens, Oculus Quest, and the NASA Mars rovers).

Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab. By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.


Note: If you are interested in taking UZH courses, you must register as an incoming mobility student at UZH. For details, see as follows:

- **UZH course enrollment for ETH student at University of Zurich (UZH)** > Mobility within Switzerland – Incoming > Module Mobility: The easiest way to take individual modules/courses to supplement your studies at your home university is with module mobility. This option is not available to students who have dropped out of their home university or have been definitely excluded or banned from the relevant program. Applications are submitted via the UZH application portal [https://www.uzh.ch/cmsssl/en/studies/application/chmobility.html](https://www.uzh.ch/cmsssl/en/studies/application/chmobility.html).
- **Step-by-step guidelines on how ETH students can register for this course**, are given on the official course website: [https://www.uzh.ch/cmsssl/en/studies/application/chmobility.html](https://www.uzh.ch/cmsssl/en/studies/application/chmobility.html).

**ATTENTION:** When you book the course at UZH, you are automatically registered for the exam at UZH and you can unregister until the October deadline. After registering for the course, you as an ETH student need to check out your **“UZH email account”** to receive the related information from the lecturer.

**Skills for Creativity and Innovation**

- Basic knowledge about creativity and skills
- Knowledge about individual prerequisites for creativity
- Development of individual skills for creativity
- Knowledge about teams
- Development of team-oriented skills for creativity
- Knowledge and know-how about transfer to idea generation teams

**Abstract**

This lecture aims to enhance the knowledge and competency of students regarding their innovation capability. An overview on prerequisites of and different skills for creativity and innovation in individual & team settings is given. The focus of this lecture is clearly on building competencies - not just acquiring knowledge.

- **Objective**
  - Basic knowledge about creativity and skills
  - Knowledge about individual prerequisites for creativity
  - Development of individual skills for creativity
  - Knowledge about teams
  - Development of team-oriented skills for creativity
  - Knowledge and know-how about transfer to idea generation teams

- **Content**
  - Basic knowledge about creativity and skills:
    - Introduction into creativity & innovation: definitions and models
  - Knowledge about individual prerequisites for creativity:
    - Personality, motivation, intelligence
  - Development of individual skills for creativity:
    - Focus on creativity as problem analysis & solving
    - Individual skills in theoretical models
    - Individual competencies: exercises and reflection
  - Knowledge about teams:
    - Definitions and models
    - Roles in innovation processes
  - Development of team-oriented skills for creativity:
    - Idea generation and development in teams
    - Cooperation & communication in innovation teams
  - Knowledge and know-how about transfer to idea generation teams:
    - Self-reflection & development planning
    - Methods of knowledge transfer

**Prerequisites / notice**

- Applications of biomedical microrobots
- Methods of knowledge transfer
- Self-reflection & development planning
- Principles of organization and communication in innovation teams
- Individual skills and competencies in innovation teams

**Lecture notes**

Slides, script and other documents will be distributed via moodle.ethz.ch (access only for students registered to this course).

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**Course Information**

- **Course Code:** 151-0632-00L
- **Course Name:** Vision Algorithms for Mobile Robotics (University of Zurich)
- **Instructor:** D. Scaramuzza
- **Credits:** 6 credits
- **Module Code:** DINF2039
- **Enrolment:** [http://rpg.ifi.uzh.ch/teaching.html](http://rpg.ifi.uzh.ch/teaching.html)
- **Literature**
  - An Invitation to 3D Vision, by Y. Ma, S. Soatto, J. Kosecka, S.S. Sastry.
  - Multiple view Geometry, by R. Hartley and A. Zisserman.
  - Fundamentals of algebra, geometry, matrix calculus, and Matlab programming.

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**Course Information**

- **Course Code:** 151-0655-00L
- **Course Name:** Skills for Creativity and Innovation
- **Instructor:** I. Goller, C. Kobe
- **Credits:** 4 credits
- **Module Code:** DINF2039
- **Enrolment:** [http://rpg.ifi.uzh.ch/teaching.html](http://rpg.ifi.uzh.ch/teaching.html)
- **Literature**
  - An Invitation to 3D Vision, by Y. Ma, S. Soatto, J. Kosecka, S.S. Sastry.
  - Multiple view Geometry, by R. Hartley and A. Zisserman.
Adaptability and Flexibility


Future training on selected current topics of the manufacturing technology. Per afternoon a selected topic is presented in several lectures, by the majority of experts from the industry. The students prepare a summary of the lectures given and prepare themselves on the basis of these lectures and own information search.

Objective
Continuous further training to current topics of the manufacturing technique. Exchange of experience and knowledge with the industry and other universities.

Content
Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

Lecture notes
no Script

Prerequisites / notice
- Students must have participated and passed the courses Manufacturing, Production Machines I and Forming Technology III - Forming Processes.
- Further training with specialized lectures and large participation from the industry.

Language: Help for English speaking students on request.

4 credits

K. Wegener

Mass Transfer

Selected actual topics on manufacturing methods and tools, machine tools, NC-control and drives, components and measuring methods and devices. Topics are changing every year.

Lecture notes
no Script

Prerequisites / notice
- Students must have participated and passed the courses Manufacturing, Production Machines I and Forming Technology III - Forming Processes.
- Further training with specialized lectures and large participation from the industry.

Language: Help for English speaking students on request.

4 credits

M. Hutter, R. Siegwart

Robot Dynamics

The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Objective

The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Lecture notes

The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

4 credits

I. Herrmann

Medical Technology Innovation - From Concept to Clinics

Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

Objective

After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

Lecture notes

will be available on the moodle.

Literature

will be available on the moodle.

Prerequisites / notice

On site presence during (most) of the lectures highly encouraged!

Fostered competencies

Subject-specific Competencies

Concepts and Theories

assessed

Techniques and Technologies

assessed

Method-specific Competencies

Analytical Competencies

assessed

Decision-making

assessed

Problem-solving

assessed

Project Management

assessed

Social Competencies

Communication

assessed

Cooperation and Teamwork

assessed

Customer Orientation

assessed

Leadership and Responsibility

assessed

Self-presentation and Social Influence

assessed

Sensitivity to Diversity

assessed

Personal Competencies

Adaptability and Flexibility

assessed

Creative Thinking

assessed

Critical Thinking

assessed

Integrity and Work Ethics

assessed

Self-awareness and Self-reflection

assessed

Self-direction and Self-management

assessed

4 credits

S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Mass Transfer

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective

This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content

Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's laws; Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; analogies for mass-, heat-, and momentum transfer in turbulent flows; film- and penetration- and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature

Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

**Abstract**

An introduction to the basic principles and interrelationships of aircraft and automotive aerodynamics. To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components. Illustration of the intrinsic problems and results using examples. Using experimental and theoretical methods to illustrate possibilities and limits.

**Content**

Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force: profile, wings. Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.


**Prerequisites / notice**

The course is self-contained and can be taken, in principle, without ACT4E I. We assume this knowledge:

1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Basic algebra (sets, posets, relations, semigroups, groups).

**Lecture notes**

Preparation materials & slides are provided prior to each class.

**Literature**

- We assume this knowledge:
  1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
  2) Basic algebra (sets, posets, relations, semigroups, groups).
Abstract
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

Objective
Understanding specific requirements and problems arising in embedded system applications.

Understanding architectures and components, their hardware-software interfaces, the memory architecture, communication between components, embedded operating systems, real-time scheduling theory, shared resources, low-power and low-energy design as well as hardware architecture synthesis.

Using the formal models and methods in embedded system design in practical applications using the programming language C, the operating system ThreadX, a commercial embedded system platform and the associated design environment.

Content
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems ThreadX, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://pbl.ee.ethz.ch/education/embedded-systems.html.

Literature


Prerequisites / notice
Prerequisites: Basic knowledge in computer architectures and programming.

227-0225-00L Linear System Theory
W 6 credits 5G J. Lygeros, A. Tsiamis

Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes
The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at https://pbl.ee.ethz.ch/education/embedded-systems.html.

Prerequisites / notice
Available on the course Moodle platform.

Sufficient mathematical maturity, in particular in linear algebra, analysis.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed

Personal Competencies
Creative Thinking
Critical Thinking not assessed
Integrity and Work Ethics not assessed

227-0447-00L Image Analysis and Computer Vision
W 6 credits 3V+1U E. Konukoglu, F. Yu

Abstract

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

Content
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

Lecture notes
Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites
Prerequisites:
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

The course language is English.
This course introduces to different electric machine concepts and provides a deeper understanding of their detailed operating principles. Different aspects arising in the design of electric machines, like dimensioning of magnetic and electric circuits as well as consideration of mechanical and thermal constraints, are investigated. The exercises are used to consolidate the concepts discussed.

The objective of this course is to convey knowledge on the operating principles of different types of electric machines. Further objectives are to evaluate machine types for given specifications and to acquire the ability to perform a rough design of an electrical machine while considering the versatile aspects with respect to magnetic, electrical, mechanical and thermal limitations. Exercises are used to consolidate the presented theoretical concepts.

- Fundamentals in magnetic circuits and electromechanical energy conversion.
- Force and torque calculation.
- Operating principles, magnetic and electric modelling and design of different electric machine concepts: DC machine, AC machines (permanent magnet synchronous machine, reluctance machine and induction machine).
- Complex space vector notation, rotating coordinate system (dq-transformation).
- Loss components in electric machines, scaling laws of electromechanical actuators.
- Mechanical and thermal modelling.

Abstract

Theory and techniques for the identification of dynamic models from experimentally obtained system input-output data. To provide a series of practical techniques for the development of dynamical models from experimental data, with the emphasis being on the development of models suitable for feedback control design purposes. To provide sufficient theory to enable the practitioner to understand the trade-offs between model accuracy, data quality and data quantity.

Introduction to modeling: Black-box and grey-box models; Parametric and non-parametric models; ARX, ARMAX (etc.) models.

Predictive, open-loop, black-box identification methods. Time and frequency domain methods. Subspace identification methods.

Optimal experimental design, Cramer-Rao bounds, input signal design.

Parametric identification methods. On-line and batch approaches.

Closed-loop identification strategies. Trade-off between controller performance and information available for identification.


Additional papers will be available via the course Moodle.

Control systems (227-0216-00L) or equivalent.

Abstract

Current topics in Systems and Control presented mostly by external speakers from academia and industry.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Autumn Semester 2022
How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

The course will introduce students to several methods of analysing the user experience, showing how these can be used at different stages of system development from requirements analysis through to usability testing. Students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

### Probabilistic Artificial Intelligence

**Number of participants limited to 150.**

**Abstract**

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

The goal of the course is to enable participants to implement solutions for reasonably complex problems. The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.

**Content**

Topics covered:

- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming.

### Computer Vision

**Abstract**

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.

**Objective**

The objectives of this course are:

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

**Content**

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

**Prerequisites / notice**

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

### Rehabilitation Engineering II: Rehabilitation of Sensory and Vegetative Functions

**Abstract**

Rehabilitation Engng is the application of science and technology to ameliorate the handicaps of individuals with disabilities to reintegrate them into society. The goal is to present classical and new rehabilitation engineering principles applied to compensate or enhance motor, sensory, and cognitive deficits. Focus is on the restoration and treatment of the human sensory and vegetative system.

**Objective**

Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.
Content

Introduction, problem definition, overview
Rehabilitation of visual function
- Anatomy and physiology of the visual sense
- Technical aids (glasses, sensor substitution)
- Retina and cortex implants
Rehabilitation of hearing function
- Anatomy and physiology of the auditory sense
- Hearing aids
- Cochlea Implants
Rehabilitation and use of kinesthetic and tactile function
- Anatomy and physiology of the kinesthetic and tactile sense
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)
- Role of displays in motor learning
Rehabilitation of vestibular function
- Anatomy and physiology of the vestibular sense
- Rehabilitation strategies and devices (e.g. BrainPort)
Rehabilitation of vegetative Functions
- Cardiac Pacemaker
- Phrenic stimulation, artificial breathing aids
- Bladder stimulation, artificial sphincter
- Deep brain stimulation for patients with Parkinson, epilepsy, depression
- Brain-Computer Interfaces

Literature

Introductory Books:

Selected Journal Articles and Web Links:

Prerequisites / notice

Target Group:
- Students of higher semesters and PhD students of
- D-MAVT, D-ITET, D-INFK, D-HEST
- Biomedical Engineering, Robotics, Systems and Control
- Medical Faculty, University of Zurich
- Students of other departments, faculties, courses are also welcome

This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

376-1504-00L  Physical Human Robot Interaction (pHRI)  W  4 credits  2V+2U  O. Lambercy
This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de-sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) Identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) Compare and select mechatronic components that optimally fulfill the defined design requirements;
3) Derive a model of the physical system that gives and optimize the selection and integration of selected components into a functional system;
4) Design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) Characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) Investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

The course will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor/quantization, etc.) during rendering of different mechanical properties.

Lecturers: S. M. Martin, J. H. Walther

Lectures: Will be distributed on Moodle before the lectures.

Literature:


Micro & Nanosystems
The courses listed in this category “Core Courses” are recommended. Alternative courses can be chosen in agreement with the tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0107-20L</td>
<td>W</td>
<td>High Performance Computing for Science and Engineering (HPCE)</td>
<td>4</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
</tbody>
</table>

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes

https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/ Class notes, handouts

Literature

• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
• Lecture notes

Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

151-0409-00L Multiphysics Modeling and Simulation 4 credits 2V+2U C. I. Roman

Abstract

This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

Objective

As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling.

Content

- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

Lecture notes

Lecture handouts will be posted online.

Literature

• Concepts and Theories
• Techniques and Technologies
• Analytical Competencies
• Decision-making
• Media and Digital Technologies
• Problem-solving
• Project Management

Subject-specific Competencies

Social Competencies

Method-specific Competencies

Personal Competencies

Fostered competencies

4 credits 3G B. Nelson
Abstract
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.

Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of microrobotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetism
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical microrobots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

<table>
<thead>
<tr>
<th>151-0605-00L</th>
<th>Nanosystems</th>
<th>W</th>
<th>4 credits</th>
<th>4G</th>
<th>A. Stemmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures. Special emphasis on the emerging field of molecular electronic devices.</td>
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<tr>
<td>Objective</td>
<td>Familiarize students with basic science and engineering principles governing the nano domain.</td>
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<tr>
<td>Content</td>
<td>The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected. Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled. Topics are treated in 2 blocks: (I) From Quantum to Continuum From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles. (II) Interaction Forces on the Micro and Nano Scale Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures.</td>
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| Prerequisites / notice | Course format: Lectures and Mini-Review presentations: Thursday 10-13 Homework: Mini-Review (compulsory continuous performance assessment) Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper. | | | | |

<table>
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<tr>
<th>151-0620-00L</th>
<th>Embedded MEMS Lab</th>
<th>W</th>
<th>5 credits</th>
<th>3P</th>
<th>C. Hierold, M. Haluska</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access</td>
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<tr>
<td>Objective</td>
<td>Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.</td>
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<tr>
<td>Content</td>
<td>With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out: Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures Packaging and electrical connection of a MEMS device Testing and characterization of the MEMS device Written documentation and evaluation of the entire production, processing and characterization</td>
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<tr>
<td>Lecture notes</td>
<td>A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.</td>
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</table>

| Literature   | The document provides sufficient information for the participants to successfully participate in the course. | | | | |
**Prerequisites / notice**

Participating students are required to attend all scheduled lectures and meetings of the course.

Participating students are required to provide proof that they have personal accident insurance prior to the start of the laboratory portion of the course.

For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

**Priority 1**: master students of the master's program in "Micro and Nanosystems"

**Priority 2**: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

**Priority 3**: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.

**Priority 4**: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.

Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.

The course is offered in autumn and spring semester.

<table>
<thead>
<tr>
<th>151-0621-00L</th>
<th>Microsystems I: Process Technology and Integration</th>
<th>W</th>
<th>6 credits</th>
<th>3V+3U</th>
<th>M. Haluska, C. Hierold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and -devices by a sequence of defined processing steps (process flow).</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystems devices by the combination of unit process steps (= process flow).</td>
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</tbody>
</table>
| **Content**   | - Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)  
- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.  
- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.  
Application of selected technologies will be demonstrated on case studies. |
| **Lecture notes** | Handouts (available online) |
| **Literature** | - S.M. Sze: Semiconductor Devices, Physics and Technology  
- W. Menz, J. Mohr, O.Paul: Microsystem Technology  
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology  
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications |
| **Prerequisites / notice** | Prerequisites: Physics I and II |

<table>
<thead>
<tr>
<th>151-0642-00L</th>
<th>Seminar on Micro and Nanosystems</th>
<th>Z</th>
<th>0 credits</th>
<th>1S</th>
<th>C. Hierold</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Scientific presentations from the field of Micro- and Nanosystems</td>
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<tr>
<td><strong>Objective</strong></td>
<td>In particular, the seminar addresses students, who are interested in scientific work in the field of Micro- and Nanosystem technologies, or who have started already with it. Respectively, current examples in the research will be discussed.</td>
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<tr>
<td><strong>Content</strong></td>
<td>Current themes in the field of Micro- and Nanosystem technologies using the examples of intern and extern research groups, as well as ongoing themes of study-, diploma- and doctoral thesis will be introduced and discussed. The scope of the seminar is broaden by occasional guest speakers.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
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<tr>
<td><strong>Literature</strong></td>
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<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Master of MNS, MAVT, ITET, Physics</td>
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<tr>
<th>151-0913-00L</th>
<th>Introduction to Photonics</th>
<th>W</th>
<th>4 credits</th>
<th>2V+2U</th>
<th>R. Quidant, J. Ortega Arroyo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.</td>
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</table>
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature

Prerequisites / notice
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.

151-0931-00L Seminar on Particle Technology
Z 0 credits 3S S. E. Pratsinis, V. Mavrantzas, C.-J. Shih

Objective
The goal of the lecture is to convey a basic knowledge in the area of PV materials as well as their construction and production processes and to empower the students to apply the knowledge gained to address current problems in research and practice.

Students attend and give research presentations for the research they plan to do and at the end of the semester they defend their results and answer questions from research scientists. Familiarize the students with the latest in this field.

151-0931-00L Information Systems for Engineers
W 4 credits 2V+1U G. Fourny

Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.
Abstract
This course provides the basics of relational databases from the perspective of the user. We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Objective
Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality.
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content
Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature
- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice
The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only. BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python.
## Bioengineering

The courses listed in this category “Core Courses” are recommended. Alternative courses can be chosen in agreement with the tutor.

### Number: 151-0107-20L

**Course Title:** High Performance Computing for Science and Engineering (HPCSE) I

**Type:** W  
**ECTS:** 4 credits  
**Hours:** 4G  
**Lecturers:** S. M. Martin, J. H. Walther

### Abstract

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering. With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

### Content

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)

2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)

3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models

4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis

5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

### Lecture notes

- Class notes, handouts
- https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/
- Literature:  
  - An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann  
  - Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press  
  - Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann  
  - Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press  
  - Lecture notes

### Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

### Number: 151-0317-00L

**Course Title:** Visualization, Simulation and Interaction - Virtual Reality II

**Type:** W  
**ECTS:** 4 credits  
**Hours:** 3G  
**Lecturers:** A. Kunz

### Abstract

This course provides deeper knowledge on the possible applications of virtual reality, its basic technology, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

### Objective

Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems. The goal of the lecture is to provide a deeper knowledge of today’s VR environments that are used in business processes. The technical background, the algorithms, and the applied methods are explained more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

### Content

- Introduction to Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

### Lecture notes

- The handout is available in German and English.

### Prerequisites / notice

- "Visualization, Simulation and Interaction - Virtual Reality I" is recommended, but not mandatory.

### Didactical concept:

- The course consists of lectures and exercises.

### Fostered competencies

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Upon completion of the course, students are able to:

- Understand the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Objective

This course is meant for engineers who are interested in pursuing an ethical and relevant career internationally, and who are willing to examine the complex role that well-meaning foreigners have played and continue to play in the disappointing health outcomes that characterize much of the African continent.

After completing the course, participants will be able to:

- Critique the jargon and terms used by the international community, i.e. “development”, “aid”, “cooperation”, “assistance” “third world” developing “global south” “low and middle-income” and justify their own chosen terminology
- Recognize the role of racism and white-supremacy in the development of the aid industry
- Understand the political, financial, and cultural reasons why technology and infrastructure have historically failed
- Debate the merits of international engineering in popular culture and media
- Propose improved SDG indicators that address current shortcomings
- Compare the engineering curricula of different countries to identify relative strengths and shortcomings
- Explain the inherent biases of academic publishing and its impact on engineering failure
- Analyse linkages between the rise of philanthropy and strategic priority areas
- Recommend equitable, just funding models to achieve more sustainable outcomes
- Formulate a vision for the international engineer of the future

Content

Role of international engineering during colonialism

- Transition of international engineering following colonialism
- White saviourism and racism in international engineering
- International engineering in popular culture
- The missing role of Engineering Education
- Biases academic publishing
- The emerging role in Global Philanthropy
- The paradox of International funding

Literature

- Moyo, D. (2009); Dead aid: Why aid is not working and how there is a better way for Africa. Macmillan.
Abstract
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

Objective
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

Content
History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.
Lectures (2h), discussion of practical exercises (1h) and homework exercises.

Lecture notes
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

AND

moodle page of the course

Prerequisites / notice
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Social Competencies
Communication assessed
Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-direction and Self-management not assessed

Abstract
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

Objective
During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectronic signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

### Content

1. Introduction
2. Membrane and Transport
3-4. Action potential and Hodgkin-Huxley
5. Measuring bioelectric signals
6. Measuring currents in solutions, nanopore sensing and patch clamp pipettes
7. Measuring potentials in solution and core conductance model
8. Measuring electronic signals with wearable electronics, ECG, EEG
9. Measuring mechanical signals with bioelectronics
10. Optical recording and control of neurons (optogenetics)
11. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

### Prerequisites

- Basic concepts of mathematical analysis and linear algebra
- The computer exercises are based on Python and Linux.

### Literature

- Plonsey and Barr, Bioelectricity: A Quantitative Approach (Third edition)

### Lecture notes

A detailed script is provided to each lecture including the exercises and their solutions.

### Methods

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptable and Flexible
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Communication
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### Cell Biophysics

Applying two fundamental principles of thermodynamics (entropy maximization and Gibbs energy minimization), an analytical model is derived for a variety of biological phenomena at the molecular as well as cellular level, and critically compared with the corresponding experimental data in the literature.
Objective

Engineering uses the laws of physics to predict the behavior of a system. Biological systems are so diverse and complex prompting the question whether we can apply unifying concepts of theoretical physics coping with the multiplicity of life's mechanisms.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann's law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding available experimental results.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Content

- Basics of theory of probability
- Boltzmann's law
- Entropy maximization and Gibbs free energy minimization
- Ligand-receptor: two-state systems and the MWC model
- Random walks, diffusion, crowding
- Electrostatics for salty solutions
- Elasticity: fibers and membranes
- Molecular motors
- Action potential: Hodgkin-Huxley model
- Photosynthesis and vision
- Gene regulation
- Development: Turing patterns
- Sequences and evolution

Lecture notes

No lecture notes because the two proposed textbooks are more than exhaustive!

Literature


Prerequisites / notice

Participants need a good command of:
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Fostered competencies

227-0945-00L Cell and Molecular Biology for Engineers I W 3 credits 2G to be announced

Does not take place this semester.

Abstract

The course gives an introduction into cellular and molecular biology, specifically for students with a background in engineering. The focus will be on the basic organization of eukaryotic cells, molecular mechanisms and cellular functions. Textbook knowledge will be combined with results from recent research and technological innovations in biology.

Objective

After completing this course, engineering students will be able to apply their previous training in the quantitative and physical sciences to modern biology. Students will also learn the principles how biological models are established, and how these models can be tested.

Content

Lectures will include the following topics (part I and II): DNA, chromosomes, genome engineering, RNA, proteins, genetics, synthetic biology, gene expression, membrane structure and function, vesicular traffic, cellular communication, energy conversion, cytoskeleton, cell cycle, cellular growth, apoptosis, autophagy, cancer and stem cells.

In addition, 4 journal clubs will be held, where recent publications will be discussed (2 journal clubs in part I and 2 journal clubs in part II). For each journal club, students (alone or in groups of up to three students) have to write a summary and discussion of the publication. These written documents will be graded and count as 40% for the final grade.

Lecture notes

Scripts of all lectures will be available.

Literature

Cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course will

**Fostered competencies**

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**227-0965-00L** Micro and Nano-Tomography of Biological Tissues  
**W** 4 credits  **3G**  **M. Stampanoni**, F. Marone Welford

**Abstract**  
The lecture introduces the physical and technical know-how of X-ray tomographic microscopy. Several X-ray imaging techniques (absorption-, phase- and darkfield contrast) will be discussed and their use in daily research, in particular biology, is presented. The course discusses the aspects of quantitative evaluation of tomographic data sets like segmentation, morphometry and statistics.

**Objective**  
Introduction to the basic concepts of X-ray tomographic imaging. Image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

**Content**  
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

**Lecture notes**  
Will be indicated during the lecture.

**227-0981-00L** Cross-Disciplinary Research and Development in Medicine and Engineering  
**W** 4 credits  **2V+2A**  **V. Kurtcuoglu**, D. de Julen de Zelicourt, M. Meboldt, M. Schmid Daners, O. Ullrich

**Abstract**  
Cross-disciplinary collaboration between engineers and medical doctors is indispensable for innovation in health care. This course will bring together engineering students from ETH Zurich and medical students from the University of Zurich to experience the rewards and challenges of such interdisciplinary work in a project based learning environment.

**Objective**  
The main goal of this course is to demonstrate the differences in communication between the fields of medicine and engineering. Since such differences become the most evident during actual collaborative work, the course is based on a current project in physiology research that combines medicine and engineering. For the engineering students, the specific aims of the course are to:

- Acquire a working understanding of the anatomy and physiology of the investigated system;
- Identify the engineering challenges in the project and communicate them to the medical students;
- Develop and implement, together with the medical students, solution strategies for the identified challenges;
- Present the found solutions to a cross-disciplinary audience.

**Content**  
After a general introduction to interdisciplinary communication and detailed background on the collaborative project, the engineering students will team up with medical students to find solutions to a biomedical challenge. In the process, they will be supervised both by lecturers from ETH Zurich and the University of Zurich, receiving coaching customized to the project. The course will end with each team presenting their solution to a cross-disciplinary audience.

**Lecture notes / Prerequisites / notice**  
Handouts and relevant literature will be provided.

**IMPORTANT:** Note that a special permission from the lecturers is required to register for this course. Contact the head lecturer to that end.

**252-0834-00L** Information Systems for Engineers  
**W** 4 credits  **2V+1U**  **G. Fourny**

**Abstract**  
This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).
Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This course teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logic
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python
Strategies of human-system-interaction, individual needs, physical & mental abilities, and system properties are key factors affecting the mechanobiological response of bone to loading and injury in scenarios relevant for personalized health and translational medicine.

Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis. To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy. Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health. Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic. Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

For the seminar, concepts of video lectures will be used in a flipped classroom setup, where students can study the basic biology, engineering, and mathematical concepts in video tutorials online (TORQUEs). All videos and animations will be incorporated in Moodle and PolyBook allowing studying and interactive course participation online. It is anticipated that the students need to prepare 2x45 minutes for the study of the actual lecture material. The course is structured as a seminar in three parts of 45 minutes with video lectures and a flipped classroom setup. In the first part (TORQUEs: Tiny, Open-with-Restrictions courses focused on QUality and Effectiveness), students study the basic concepts in short, interactive video lectures on the online learning platform Moodle. Students are able to post questions at the end of each video lecture or the Moodle forum that will be addressed in the second part of the lectures using a flipped classroom concept. For the flipped classroom, the lecturers may prepare additional teaching material to answer the posted questions (Q&A). Following the Q&A, the students will have to form small groups to try to solve such problems and to present their solutions for advanced multiscale investigation of bone ranging from basic science to clinical application. Towards the end of the semester, students will have to present self-selected publications associated with the different topics of the lecture identified through PubMed or the Web of Science.

### Content
- Bone is one of the most investigated biological materials due to its primary function of providing skeletal stability. Bone is susceptible to different local stimuli including mechanical forces and has great capabilities in adapting its mechanical properties to the changes in its environment. Nevertheless, aging or hormonal changes can make bone lose its ability to remodel appropriately, with loss of strength and increased fracture risk as a result, leading to devastating diseases such as osteoporosis.
- To better understand the biomechanical function of bone, one has to understand the hierarchical organization of this fascinating material down from the molecules, to the cells, tissue and up to the organ. Multiscale imaging and simulation allow to link these different levels of hierarchy.
- Incorporating systems biology approaches, not only biomechanical strength of the material can be assessed but also the mechanobiological response of the bone triggered by loading and injury in scenarios relevant for personalized health.
- Watching cells working together to build and repair bone in a coordinated fashion is a spectacle, which will need dynamic image content and deep discussions in the lecture room to probe the imagination of the individual student interested in the topic.
- Lastly, state-of-the-art developments in tissue engineering and regeneration, 3D bioprinting and bio-manufacturing and organoid technology will be highlighted towards personalized health.

### License notes
Material will be provided on Moodle and eColab.

### Prerequisites / notice
Prior experience with the programming language python is beneficial but not mandatory. ETH offers courses for practical programming with python.

### Objectives
- Provide knowledge on the anatomy and physiology of the human sensory system, related dysfunctions and pathologies, and how rehabilitation engineering can provide sensory restoration and substitution.
- Fostered competencies
  - Subject-specific Competencies: Concepts and Theories
  - Method-specific Competencies: Analytical Competencies
  - Social Competencies: Communication
  - Personal Competencies: Creative Thinking
- Assessed skills
  - Techniques and Technologies
  - Decision-making
  - Sensitivity to Diversity
  - Integrity and Work Ethics
**Content**

Introduction, problem definition, overview  
Rehabilitation of visual function  
- Anatomy and physiology of the visual sense  
- Technical aids (glasses, sensor substitution)  
- Retina and cortex implants  
- Rehabilitation of hearing function  
- Anatomy and physiology of the auditory sense  
- Hearing aids  
- Cochlea Implants  
- Rehabilitation and use of kinesthetic and tactile function  
- Anatomy and physiology of the kinesthetic and tactile sense  
- Tactile/haptic displays for motion therapy (incl. electrical stimulation)  
- Role of displays in motor learning  
- Rehabilitation of vestibular function  
- Anatomy and physiology of the vestibular sense  
- Rehabilitation strategies and devices (e.g. BrainPort)  
- Cardiac Pacemaker  
- Phrenic stimulation, artificial breathing aids  
- Bladder stimulation, artificial sphincter  
- Brain stimulation and recording  
- Deep brain stimulation for patients with Parkinson, epilepsy, depression  
- Brain-Computer Interfaces  

**Literature**

Introductory Books:  

Selected Journal Articles and Web Links:  

**Prerequisites / notice**

Target Group:  
Students of higher semesters and Phd students of  
- D-MAVT, D-ITET, D-INFK, D-HEST  
- Biomedical Engineering, Robotics, Systems and Control  
- Medical Faculty, University of Zurich  
Students of other departments, faculties, courses are also welcome  
This lecture is independent from Rehabilitation Engineering I. Thus, both lectures can be visited in arbitrary order.

**376-1504-00L**  
Physical Human Robot Interaction (pHRI)  
W 4 credits 2V+2U  
O. Lambercy
This course focuses on the emerging, interdisciplinary field of physical human-robot interaction, bringing together themes from robotics, real-time control, human factors, haptics, virtual environments, interaction design and other fields to enable the development of human-oriented robotic systems.

The objective of this course is to give an introduction to the fundamentals of physical human-robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.

By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de-sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:

1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;
2) compare and select mechatronic components that optimally fulfill the defined design requirements;
3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;
4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;
5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;
6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.

This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and lab visits.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be implemented in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes
Will be distributed on Moodle before the lectures.

Literature

Prerequisites / notice
Notice:
The registration is limited to 26 students
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.
http://www.relab.ethz.ch/education/courses/phri.html

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lectures</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1515-00L</td>
<td>Clinical and Movement Biomechanics</td>
<td>4</td>
<td>Number of participants limited to 50.</td>
</tr>
<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>4</td>
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</tbody>
</table>
Abstract
Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts will be made available. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Literature

Handouts and references therin.

376-1985-00L Trauma Biomechanics

Abstract
Trauma biomechanics in an interdisciplinary research field investigating the biomechanics of injuries and related subjects such as prevention. The lecture provides an introduction to the basic principles of trauma biomechanics.

Objective
Introduction to the basic principles of trauma biomechanics.

Content
This lecture serves as an introduction to the field of trauma biomechanics. Emphasis is placed on the interdisciplinary nature of impact biomechanics, which uses the combination of fundamental engineering principles and advanced medical technologies to develop injury prevention measures. Topics include: accident statistics and accident reconstruction, biomechanical response of the human to impact loading, injury mechanisms and injury criteria, test methods (including crash tests), computer simulations, aspects of vehicle safety. Real world examples mainly from automobile safety are used to augment lecture material.

Lecture notes
Handouts will be made available.

Literature

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making not assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity assessed

Personal Competencies
- Negotiation not assessed
- Adaptability and Flexibility not assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

402-0341-00L Medical Physics I

Abstract
Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.

Objective
Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

Content
The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the excercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

Lecture notes
A script will be provided.

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

551-0319-00L Cellular Biochemistry (Part I)

Abstract

Objective

Content

Fostered competencies

Subject-specific Competencies

Method-specific Competencies

Social Competencies

Personal Competencies

4 credits
2V+1U
K.-U. Schmitt, M. H. Muser
3 credits
2V
U. Kutay, G. Neurohr, M. Peter, I. Zemp
Abstract

Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective

The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterization of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Content

Structural and functional details of individual cell components, regulation of their interactions, and various aspects of the regulation and compartmentalisation of biochemical processes.

Topics include: biophysical and electrical properties of membranes; viral membranes; structural and functional insights into intracellular transport and targeting; vesicular trafficking and phagocytosis; post-transcriptional regulation of gene expression.

Lecture notes

Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature

Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice

To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

Design, Computation, Product Development & Manufacturing

The courses listed in this category “Core Courses” are recommended. Alternative courses can be chosen in agreement with the tutor.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-3209-00L</td>
<td>Engineering Design Optimization</td>
<td>W</td>
<td>4</td>
<td>4G</td>
<td>K. Shea, T. Stankovic</td>
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<td></td>
<td>Number of participants limited to 60.</td>
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<tr>
<td>Abstract</td>
<td>The course covers fundamentals of computational optimization methods in the context of engineering design. It develops skills to formally state and model engineering design tasks as optimization problems and select appropriate methods to solve them.</td>
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<tr>
<td>Objective</td>
<td>The lecture and exercises teach the fundamentals of optimization methods in the context of engineering design. After taking the course students will be able to express engineering design problems as formal optimization problems. Students will also be able to select and apply a suitable optimization method given the nature of the optimization model. They will understand the links between optimization and engineering design in order to design more efficient and performance optimized technical products. The exercises are MATLAB based.</td>
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<tr>
<td>Lecture notes</td>
<td>available on Moodle</td>
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<tr>
<td>151-3215-00L</td>
<td>Design for Additive Manufacturing</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>M. Meboldt, J. Ferchow</td>
</tr>
<tr>
<td></td>
<td>Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: <a href="mailto:ferchow@ethz.ch">ferchow@ethz.ch</a>).</td>
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<tr>
<td>Abstract</td>
<td>This course focuses on the design, fabrication, and testing of components produced by additive manufacturing (AM) technologies. The course includes a project based on a real-world problem in which students design, fabricate and iteratively optimize functional AM parts using an appropriate AM technology.</td>
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<tr>
<td>Objective</td>
<td>In this course fundamental knowledge of Design for Additive Manufacturing (AM). The course will prepare the students to:</td>
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<td>- Apply fundamental AM processes (metal and plastics)</td>
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<td>- Apply the AM design guidelines</td>
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<td>- Adopt AM in an industrial environment</td>
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<td>- Apply design tools and methods in AM</td>
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<td>- Create an added value of AM</td>
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<td>- Work in a project-based product development team</td>
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<tr>
<td>Content</td>
<td>Parallel to the lectures the students design, manufacture and test prototypes in a project in different product development stages. The course is addressing the following topics:</td>
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<td>- State of the art AM Processes for metal and plastics (LPBF, BJ, MJF, SLS, FDM)</td>
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<td></td>
<td>- Design guidelines in AM</td>
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<td>- Industrial adoption of AM</td>
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<td></td>
<td>- Value creation and business models for AM</td>
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<tr>
<td></td>
<td>- Design tools and methods for AM</td>
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<td>- Quality management in AM</td>
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<td>- Industry cases of AM applications</td>
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<td>- Problem solving and creativity</td>
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<td></td>
<td>- Agile Development</td>
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<tr>
<td>Lecture notes</td>
<td>Script and handouts are available in PDF-format.</td>
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<tr>
<td>Literature</td>
<td>Christoph Klahn; Mirko Meboldt: Entwicklung und Konstruktion für die Additive Fertigung - Grundlagen und Methoden für den Einsatz in industriellen Endkundenprodukten</td>
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<td></td>
<td>Vogel Business Media, Würzburg</td>
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<tr>
<td></td>
<td>ISBN: 978-3-8343-3395-7</td>
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<td></td>
<td>Ian Gibson; David Rosen; Brent Stucker: Additive manufacturing technologies - 3D printing, rapid prototyping, and direct digital manufacturing</td>
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<tr>
<td></td>
<td>Springer, New York</td>
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<td></td>
<td>ISBN: 978-1-4939-2112-6</td>
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</tbody>
</table>
This course is for master's students.

Please write a short motivation letter to apply for the course. The motivation letter should include why you intend to visit the course. Additionally, please mention what experience you have with relevant topics, such as CAD, project work, additive manufacturing (AM), simulation or design of experiments. Please also mention in the letter, if you already have a proposal for an AM component to be designed as part of the project or if you have a real-world challenge you could address by AM. Please send the letter to Julian Ferchow (email: ferchow@ethz.ch).

The successful completion of the course requires active participation in the project, the lecture and the oral exam.

Final grades are based on the performance in the projects, the oral examination and the performance and the participation in the lecture.

252-0834-00L Information Systems for Engineers W 4 credits 2V+1U G. Fourny

Abstract

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it.

The course also covers support for data cubes (analytics).

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

Content

Using a relational database
1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level
6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database
12. Data cubes

Outlook

13. Outlook

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)
Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BSc and MSc

Elementary knowledge of set theory and logic

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Fostered competencies

Subject-specific Competencies: Concepts and Theories, assessed
Techniques and Technologies, assessed

Method-specific Competencies: Analytical Competencies, assessed
Decision-making, assessed
Media and Digital Technologies, not assessed
Problem-solving, not assessed

Social Competencies: Communication, not assessed
Sensitivity to Diversity, not assessed
Negotiation, not assessed

Personal Competencies: Creative Thinking, not assessed
Critical Thinking, not assessed
Integrity and Work Ethics, not assessed

Fostered competencies

Concepts and Theories, assessed

Techniques and Technologies, assessed

Analytical Competencies, assessed
Decision-making, assessed

Media and Digital Technologies, not assessed
Problem-solving, not assessed

Communication, not assessed
Sensitivity to Diversity, not assessed
Negotiation, not assessed

Creative Thinking, not assessed
Critical Thinking, not assessed
Integrity and Work Ethics, not assessed

Multidisciplinary Courses

The students are free to choose individually Master's courses from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1002-00L</td>
<td>Semester Project Mechanical Engineering</td>
<td>O</td>
<td>8</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

The subject of the Semester Project and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

Abstract

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program.

Industrial Internship

<table>
<thead>
<tr>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>8</td>
<td>external organisers</td>
<td></td>
</tr>
</tbody>
</table>

Access to the company list and request for recognition under www.mavt.ethz.ch/praxis.

No registration required via myStudies.

Abstract

The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Objective

The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-1001-00L</td>
<td>Master's Thesis Mechanical Engineering</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Students who fulfill the following criteria are allowed to begin with their Master's Thesis:

a. successful completion of the bachelor program;

b. fulfilling of any additional requirements necessary to gain admission to the master programme;

c. successful completion of the semester project and industrial internship;

d. achievement of 28 ECTS in the category "Core Courses".

The Master's Thesis must be approved in advance by the tutor and is supervised by a professor of ETH Zurich.

Abstract

Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

Objective

The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.
Linear Algebra I and II  
**ECTS:** 6 credits  
**Hours:** 13R  
**Lectures:** N. Hungerbühler

**Abstract**
Linear algebra is an indispensable tool of engineering mathematics. The course is an introduction to basic methods and fundamental concepts of linear algebra and its applications to engineering sciences.

**Objective**
After completion of this course, students are able to recognize linear structures and to apply adequate tools from linear algebra in order to solve corresponding problems from theory and applications. In addition, students have a basic knowledge of the software package Matlab.

**Content**

Linear maps, kernel and image, coordinates and matrices, coordinate transformations, norm of a matrix, orthogonal matrices, eigenvalues and eigenvectors, algebraic and geometric multiplicity, eigenbasis, diagonalizable matrices, symmetric matrices, orthonormal basis, condition number, linear differential equations, Jordan decomposition, singular value decomposition, examples in MATLAB, applications.

**Reading:**
Gilbert Strang "Introduction to linear algebra", Wellesley-Cambridge Press: Chapters 1-6, 7.1-7.3, 8.1, 8.2, 8.6


**Analysis III**
**ECTS:** 4 credits  
**Hours:** 9R  
**Lectures:** A. Iozzi

**Abstract**
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

**Objective**
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

**Content**
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

**Literature**

For reference/complement of the Analysis I/II courses:
Christian Blatter: Ingenieur-Analysis (Download PDF)

**Prerequisites / notice**
Up-to-date information about this course can be found at:
http://www.math.ethz.ch/education/bachelor/lectures/hs2013/other/analysis3_itet
### Mechanical Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
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</table>

### Key for Hours

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Gender Issues In Education and STEM

**Number of participants limited to 30.**

**Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).**

**Prerequisite:** students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

**Objective**
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.

**Content**
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

**Prerequisites / notice**
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

### Cognitively Activating Instructions in MINT Subjects

**Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).**

**This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)".**

**Objective**
- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

**Prerequisites / notice**
Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.

### Human Intelligence

**Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).**

**Number of participants limited to 30.**

**This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW1)".**
Understanding research methods used in the empirical human sciences

Students learn more about potentials and deficits of students. They get to know intelligence tests and research questions in group work.

Objective
- Understanding research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

851-0242-08L Research Methods in Educational Science

Number of participants limited to 30

This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Abstract
Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective
- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

851-0240-22L Coping with Psychosocial Demands of Teaching (EW 4 W DZ)

Number of participants limited to 20.

Abstract
In this class, students will learn concepts and skills for coping with psychosocial demands of teaching. The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.

Objective
Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.

Content
(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

851-0228-00L Formation of Knowledge in STEM Fields in Primary and Secondary School

Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enrolled after successful participation in the course 851-0240-00L "Human Learning (EW 1)".

Abstract
The event includes a block seminar as well as an assistance period in a primary or secondary school. It part is of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

Objective
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

Content
Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

Subject Didactics and Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Number Title Type ECTS Hours Lecturers
151-1079-00L Teaching Internship Including Examination Lessons Mechanical and Process Engineering W 6 credits 13P Q. Lohmeyer

Abstract
The teaching internship can just be visited if all other courses of TC are completed. Repetition of the teaching internship is excluded even if the examination lessons are to be repeated.

Objective
- Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Grade</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1072-00L</td>
<td>Mentored Thesis in Didactics of Mechanical and Process Engineering</td>
<td>2</td>
<td>4A</td>
<td>Q. Lohmeyer</td>
</tr>
<tr>
<td>227-0857-00L</td>
<td>Didactics I for D-MAVT and D-ITET</td>
<td>4</td>
<td>3G</td>
<td>Q. Lohmeyer, R. Büchi</td>
</tr>
</tbody>
</table>

**Abstract**

The purpose of the mentored thesis is to bring together the findings from didactics and to expand them by incorporating specific teaching techniques and teaching methods. The thesis can be thematically aligned with the subsequent teaching internship.

**Objective**

The students learn to link theoretical topics from the didactic education with practice-relevant aspects and to articulate the result in written form by means of a suitable task.

**Content**

The choice of the topic and the definition of the contents takes place in agreement between the students and the mentor. The topic must be chosen in such a way that the learning objective described above can be achieved.

**Lecture notes**

A short guideline is available.

**Literature**

The use of suitable literature is part of the assignment.

**Prerequisites / notice**

Prerequisite: Both didactics courses completed.

The work should be completed before the start of the internship.

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<table>
<thead>
<tr>
<th>Course Code</th>
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**Abstract**

Didactics I focuses on teaching techniques as building blocks of typical lessons. This is done on the basis of the findings of teaching and learning research and their implementation in practice. The aim is the planning and implementation of effective teaching sequences as well as their evaluation and reflection.

**Objective**

- The students can plan, conduct and critically reflect single lessons.
- They orient themselves towards the academic goals and take into account existing knowledge, the professional environment and the ambitions of the students.
- They can apply the basic teaching principles meaningfully in their subject and suitably structure the learning phases.
- They can reduce and present complex technical content such that it is in a form suitable for the students to learn.
- They have considered examples of the common conceptual errors encountered by students

**Content**

- Planning a teaching unit
- Opening a lecture
- Direct Instruction
- Blackboard writing and slide design
- Develop exercises
- Practicing teaching
- Excursion Fachhochschule

**Lecture notes**

Lecture materials are provided via Moodle.

**Prerequisites / notice**

Prerequisite: Educational science course already completed or at the same time.

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**Mechanical and Process Engineering TC - Key for Type**

<table>
<thead>
<tr>
<th>Key</th>
<th>Type</th>
<th>Description</th>
<th>Example</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>Required for the degree</td>
<td>E- Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for the degree</td>
<td>Z Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<td>Dr Suitable for doctorate</td>
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**Key for Hours**

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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
The basic physical concepts for the description of materials are taught, partly in self-study, and applied in exercises. Basic atomistic and quantum-mechanical concepts are introduced to the students. The mathematical foundation of this lecture is provided by Linear Algebra I, where students are expected to have a good command of linear algebra concepts. The lecture offers an introduction into the theory with many applications. The new notions are practised in the accompanying exercise classes. The course will be continued as Linear Algebra II. Upon completion of this course, students will be able to recognize linear structures, and to solve corresponding problems in theory and in practice.

### Content
- Systems of linear equations, Gaussian elimination, solution space, matrices, LR decomposition, Determinants, structure of linear spaces, normed vector spaces, inner products, method of least squares, QR decomposition, introduction to MATLAB, applications

### Literature
- * K. Meyberg / P. Vachenauer, Höhere Mathematik 1, Springer 2003

### Prerequisites / notice
Active participation in the exercises is part of this course. It is expected, that students submit 3/4 of all exercises for control.

### Objective
1. Students can describe the different atomic structures of metals, polymers and ceramics and derive basic material-specific properties.
2. Students are familiar with the concept of mole and molar mass and can perform stoichiometric calculations.
3. Students are able to formulate the law of mass action and, with the help of the equilibrium constant, make statements about the position of equilibrium. They understand how a chemical equilibrium reacts to changes in concentration, pressure and temperature and how to apply Le Châtelier's principle.
4. Students can define oxidation and reduction, determine oxidation numbers, assign reducing and oxidizing agents and calculate redox potentials. They can transfer the basics of redox chemistry to material science processes and applications such as corrosion or batteries.
5. They can explain the terms acid and base, understand what pH means and they can perform pH calculations. They can describe the meaning of acids and bases using material science examples.

### Analysis I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0261-G0L</td>
<td>Differential and integral calculus for functions of one and several variables; vector analysis; ordinary differential equations of first and of higher order, systems of ordinary differential equations; power series. The mathematical methods are applied in a large number of examples from mechanics, physics and other areas which are basic to engineering.</td>
<td>O</td>
<td>8 credits</td>
<td>5V+3U</td>
<td>A. Steiger</td>
</tr>
</tbody>
</table>

### Linear Algebra I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0171-00L</td>
<td>Linear algebra is an indispensable tool of engineering mathematics. The course offers an introduction into the theory with many applications. The new notions are practised in the accompanying exercise classes. The course will be continued as Linear algebra II. Upon completion of this course, students will be able to recognize linear structures, and to solve corresponding problems in theory and in practice.</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>N. Hungerbühler</td>
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### Chemistry I

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<tr>
<th>Number</th>
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<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>327-0112-00L</td>
<td>Introduction to the basics, terms and concepts of general chemistry, their application to questions in material science and their connection to laboratory experiments and projects.</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Niederberger</td>
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</table>

### Physics I

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0050-00L</td>
<td>The lecture covers the basics of classical mechanics.</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>D. Rupp</td>
</tr>
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### Foundations of Materials Science I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>327-0113-00L</td>
<td>The basic physical concepts for the description of materials are taught, partly in self-study, and applied in exercises. Basic atomistic and macroscopic concepts (e.g. phase diagrams, phase transformations, response functions) are introduced through examples. Selected topics are deepened in classroom lectures. Students are able to name the basic concepts of materials science.</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>L. Isa</td>
</tr>
</tbody>
</table>
Main textbook:
William D. Callister, Jr., David G. Rethwisch
Materials Science and Engineering - An Introduction

Alternatives:
Milton Ohring
Engineering Materials Science

James F. Shackelford
Introduction to Materials Science for Engineers

Additional First Year Basic Courses

<table>
<thead>
<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>327-0111-00L</td>
<td>Projects and Lab Courses I</td>
<td>O</td>
<td>7 credits</td>
<td>7P</td>
<td>M. B. Willeke, L. De Pietro, M. R. Dusseiller, S. Morgenthaler Kobas, T.-B. Schweizer</td>
</tr>
</tbody>
</table>

Abstract
Practical introduction to the basics of the scientific method, materials science, physics and chemistry in the form of laboratory experiments and projects, some of which are closely related to the lectures in the first year. Important chemical and physical methods are tested, project work is practiced and the basics of working safely in the laboratory are learned.

Objective
- The students
  - keep a laboratory journal independently, completely and appropriately.
  - can evaluate and display measurement data in a targeted manner.
  - are able to write laboratory reports appropriately.
  - know the communicative and rhetorical factors that are decisive for the success of an oral presentation.
  - create effective presentation documents.
  - know the general safety rules and disposal concepts for working in laboratories and apply them practically.
  - proceed correctly in case of accidents and evacuations.
  - learn practically how to fight a fire (fire protection course of the ETH).
  - apply the basic knowledge in analytics, chemistry, physics and materials science acquired in the base year in a practical way.
  - practice carrying out small experiments or small projects independently under supervision.

Content
- in the area of scientific work: Keeping lab journals, data analysis, writing reports, presentation techniques, Test preparation and introduction to safe working and behaviour in the lab.
- Lab experiments: Experiments from the fields of synthetic and analytical chemistry and experiments from the fields of physics and materials science, e.g. Mechanical/thermal properties (e.g. modulus of elasticity, fracture mechanics), thermodynamics, colloid chemistry, "particle tracking" with DLS and microscopy, surface technology, "wood, stone and metal" processing, and electrochemistry. Some practical experiments are organized as short projects (two afternoons), e.g. "Building a microscope from a webcam", etc.
- In the projects: Two "reverse engineering" projects with everyday objects: Analysis of construction and materials, functioning in the overall context, life cycle of materials, alternative materials, etc.

Prerequisites / notice
Special students and auditors need a special permission from the lecturers

Programming I

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>327-0114-00L</td>
<td>Programming I</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>L. De Pietro</td>
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</table>

Abstract
This course provides an introduction to the general computer and programming concepts, which are necessary to perform numerical calculations, representations and simulations in materials science.

Objective
- Students independently develop programs to accomplish numerical calculations, representations and simulations.
- They analyse and understand the functionality of existing programs and can supplement or adapt them according to their requirements.
- They recognize basic computer science concepts and apply algorithmic thinking, i.e. they have the ability to solve problems systematically using developed algorithms.

Content
- The course contains a first introduction to Python and Matlab. It contains:
  - Basic programming concepts of structural programming like
    - Variables
    - Lists
    - Loops
    - Branches
    - Control structures
  - Input and output
  - Modular structure of programs with functions
  - Flowcharts
  - Numerical accuracy
  - Data evaluation and presentation
    - Regression
    - Interpolation
    - Curves fit
  - Complexity Theory
  - Sorting and searching
  - Dynamic programming
  - Recursion
  - Graph Algorithms

Prerequisites / notice
Moodle, Code Expert, ...

Second Year Basic Courses

Examination Blocks

Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-0363-10L</td>
<td>Analysis III</td>
<td>O</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>A. Iozzi</td>
</tr>
</tbody>
</table>
Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

Content
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform

Lecture notes
Lecture notes by Prof. Dr. Alessandra Iozzi:
https://polybox.ethz.ch/index.php/s/D3K0TayQXvfpCAA

Literature

For reference/complement of the Analysis I/II courses:
Christian Blatter: Ingenieur-Analysis
https://people.math.ethz.ch/~blatter/dlp.html

327-0316-00L
Quantum Mechanics for Materials Scientists
O 3 credits 2V+1U S. Stepanow

Abstract
Analysis and motivation for the necessity of a theory beyond classical mechanics to describe materials properties. The principles, terminology and concepts of quantum mechanics will be introduced and mathematically represented on the basis of simple problems.

Objective
Give reasons for the necessity of quantum mechanical description of matter and explain experimental observations leading to this description.
Clarification of the term quantum object.
Formulate and solve the Schrödinger equation for simple problems.
Application of the operator formalism for the calculation of observables and the interpretation of physical processes. Interpretation of the wavefunction.
Explain the solution of the hydrogen atom. Derivation of the approach to the solution in the application of symmetries and angular momentum operators.
Give reasons for the electron spin and calculate magnetic moments.
The course teaches the basics and terminology of polymer synthesis. To synthesize various polymeric materials, different polymerization techniques are required. This course will introduce representative polymerization methodologies and will discuss how they operate in order to yield materials with enhanced polymeric characteristics.

4) The students will understand the mechanism of selected polymerization methodologies

5) The students will be introduced to state-of-the-art polymer synthesis and recent literature examples will be critically discussed

The course is intended to enable the students to select and apply the optimal analytical/spectroscopic methods for the identification of organic, inorganic and polymeric materials.

Particular emphasis is given to qualitative and quantitative analysis of material composition at the atomic/molecular level by mass spectrometry, atomic absorption, vibrational and UV-vis spectroscopy, thermal analysis, nuclear magnetic resonance. The course will include lectures as well as hands-on practical sessions.

**Examination Block 2**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>327-0312-00L</td>
<td>Materials Synthesis I - Polymers</td>
<td>O</td>
<td>4 credits</td>
<td>4G</td>
<td>A. Anastasaki, D. Opris</td>
</tr>
<tr>
<td>327-0315-00L</td>
<td>Statistical Thermodynamics</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>A. Gusev, H. C. Öttinger</td>
</tr>
<tr>
<td>327-0313-00L</td>
<td>Materials Characterization I</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>A. Lauria, A. Anastasaki</td>
</tr>
</tbody>
</table>

**Objective**

The aim of the course is to enable the students to select and apply the optimal analytical/spectroscopic methods for the identification of organic, inorganic and polymeric materials.

The course provides a solid working knowledge in thermodynamics (as the appropriate language for treating a variety of problems in materials science) and in statistical mechanics (as a systematic tool to find thermodynamic potentials for specific problems)

A guideline and a summary will be provided on the course website

**Prerequisites / notice**

4G

in German, can be downloaded at https://intermag.mat.ethz.ch/education.html

327-0313-00L Materials Characterization I O 3 credits 3G A. Lauria, A. Anastasaki

Crisis of classical physics

Planck's law of radiation (cavity radiation), photoelectric effect (Einstein's light quantum hypothesis), Bohr quantisation of the atom, De Broglie hypothesis

Wave-particle dualism - wave mechanics, matter waves, double-slit experiment, comparison of classical mechanics and quantum mechanics

Introduction of the wave function, de-Broglie relation, probability

Postulates of quantum mechanics

Introduction of the Schrödinger equation, normalisation of the wave function, stationary Schrödinger equation, location and momentum space, location representation of the momentum operator

Wave packets (Gaussian bell curve), decay of wave packets, indeterminacy principle

Wave mechanics with forces

Piecewise constant potentials, particles in the potential well, potential step, probability current density, potential wall, tunnel effect, potential well

Formalism of quantum mechanics

Hilbert space, scalar product, vectors (basis), states, normalizability, completeness, eigenfunctions, notations, operators - general definitions and properties,

Expectation values, spectrum (discrete, continuous), matrix representation, Ehrenfest theorem, measurement process and collapse of the wave function

Central potential

Eigenvalue problem in spherical coordinates, limiting cases, particles in a 3D pot, symmetries, rotation and angular momentum, angular momentum operator and spherical surface functions

Hydrogen atom

Coulomb potential, radial wave function, orbitals, atomic structure

Charged particle in electric and magnetic field, magnetic moment, Stern-Gerlach experiment, spin, vector-valued wave function, free electron in magnetic field, spin resonance

Literature


A. Messiah, Quantenmechanik I und II, de Gruyter, 1990/91.


Physik I und II, Analysis I and II, Lineare Algebra I and II, Foundations of Wahrscheinlichkeitsrechnung of Programmieren II.

Fourier-Transformation from Analysis III is used, but is not a basic requirement.
A script of the lecture until 2014 is available. Script notes for the present lecture will be provided before the start of the lecture.

Adaptability and Flexibility
You are going to address, in groups, problems that are arising or may arise in the context of remaining courses of your studies, that cannot

Development of a project plan, including modules to be created, milestones to be reached, required input data and its acquisition, tests to be

Information available at https://polyphys.mat.ethz.ch/education/courses/CTL-I.html

Title
Symmetry and order: symmetry operations and lattices in two and three dimensions, point groups, space groups.

Objective
Introduction into the fundamental relationships between crystal structure, symmetry, and physical properties of solids. Emphasis: group-

Content
Symmetry and order: symmetry operations and lattices in two and three dimensions, point groups, space groups.

Crystal structures: symmetry and geometrical factors governing the formation of crystal structures; close sphere packings; typical basic
crystal structures.

Structure/property relationships: Neumann's principle; examples: piezoelectricity, ferroelectric.

Materials characterization: diffraction techniques.

Lecture notes
A script of the lecture until 2014 is available. Script notes for the present lecture will be provided before the start of the lecture.

Literature

Prerequisites / notice
Organisation: One hour of lectures per week accompanied by one hour of exercises.

Projects and Applications

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>327-0314-00L</td>
<td>Crystallography</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>T. Lottermoser, M. Fiebig, A. Simonov, T. Weber</td>
</tr>
</tbody>
</table>

Abstract
The properties of crystals, which represent a large part of solid materials, are closely related to their structural symmetry. The aim of the lecture crystallography is to convey concepts and mathematical basics of symmetry theory, structure-property relationships, as well as the basic features of structure determination. Simple crystal structure types are discussed.

Objective
Introduction into the fundamental relationships between crystal structure, symmetry, and physical properties of solids. Emphasis: group-

Content
Symmetry and order: symmetry operations and lattices in two and three dimensions, point groups, space groups.

Crystal structures: symmetry and geometrical factors governing the formation of crystal structures; close sphere packings; typical basic crystal structures.

Structure/property relationships: Neumann's principle; examples: piezoelectricity, ferroelectric.

Materials characterization: diffraction techniques.

Lecture notes
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Literature

Prerequisites / notice
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Crystal structures: symmetry and geometrical factors governing the formation of crystal structures; close sphere packings; typical basic crystal structures.

Structure/property relationships: Neumann's principle; examples: piezoelectricity, ferroelectric.

Materials characterization: diffraction techniques.

Lecture notes
A script of the lecture until 2014 is available. Script notes for the present lecture will be provided before the start of the lecture.

Literature

Prerequisites / notice
Organisation: One hour of lectures per week accompanied by one hour of exercises.
Semester-long project, project assignment is determined at the beginning of each semester. 
Chemistry III: Synthesis of PMMA via Transesterification; PET recycling or manufacture of poly(methylmethacrylat) via radical polymerization of methylmethacrylat; 3D-printing.

Physics I, five experiments out of: reflection spectroscopy, experiments on the field of polyers, e.g. viscoelasticity of the polymer melt (or an equivalent expl.), 2 physics experiments (out of 4) at the EMPA; e.g. X-ray florescence analysis, impedance measurements of batteries, ‘power to gas’ or texture measurement, building a Lithium ionic battery; and further physic experiments.

Notes with information for each experiment (aim of the experiment, theory, experimental procedure, data analysis) can be downloaded from the web (https://praktikum.mat.ethz.ch or https://www.mat.ethz.ch/studies/bachelor/laborpraktische-ausbildung.html).


### Third Year Basic Courses

#### Individual courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>327-0512-00L</td>
<td>Electronic, Optical and Magnetic Properties of Materials</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>P. Gambardella</td>
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</tbody>
</table>

**Abstract**

This course provides physical foundations to understand the response of different classes of materials to electromagnetic fields, focusing on their electrical, optical, and magnetic properties, and on the basic functioning of devices that exploit such properties. The lectures build on classical and quantum mechanical concepts to provide microscopic understanding and modelling.

**Objective**

To provide physical concepts for the understanding of material properties as well as the functioning of basic electronic, photonic, and magnetic devices.

Understanding the electronic properties of solids is at the heart of modern society and technology. The aim of this course is to provide fundamental concepts that allow one to relate the electronic structure of different types of materials to their electrical, optical, and magnetic behavior. Beyond fundamental curiosity, such level of understanding is required in order to develop and appropriately describe new classes of materials for future technology applications. By the end of the course the student should have developed a semi-quantitative understanding of basic concepts in solid state physics and be able to appreciate the pertinence of different models to the description of specific material properties, including numerical estimates of the relevant parameters. The student should also learn to describe the working principles of a wide range of devices that are built to take advantage of such properties.

**Content**

**PART I: The electronic structure of metals, semiconductors, and insulators**

Revision of classical concepts: electric fields and currents, Ohm’s and Drude’s model of electrical conductivity, Hall effect, thermoelectric effects.

Revision of quantum mechanical concepts: Electron bands, Fermi statistics, Fermi energy and Fermi surface, density of states in k-space and as a function of energy.

**PART II: Semiconductors: concepts and devices**


**PART III: Dielectric properties of insulators**


**PART IV: Interaction of electromagnetic waves with matter**

The electromagnetic (EM) spectrum. Electromagnetic waves in vacuum; Energy, momentum, and angular momentum of EM waves; Sources of EM radiation; EM waves in matter. The refractive index. Transmission, Reflection, and Refraction from a microscopic point of view. Optical anisotropy, Optical activity, Dichroism. Optical properties of crystalline insulators and semiconductors, glasses, and metals.

**PART V: Photonic devices**

Photodiodes, photovoltaic cells, light emitting devices (LEDs), Laser diodes, displays, optical fibers.

**PART VI: Magnetism**


in English, available for download at http://www.intermag.mat.ethz.ch/education.html

**Literature**


C. Kittel, Introduction to Solid State Physics (Wiley, 2005), also printed in German. General text that covers many arguments from the point of view of condensed matter physics.


D. A. Neamen, Semiconductor Physics and Devices (McGraw-Hill, 2012). General treatment of semiconductor physics and devices, including both basic and more advanced topics.


Optics and optical materials: E. Hecht, Optics (Lehmanns) ; M. Fox, Optical Properties of Solids (Oxford U. Press)

Photonic Devices; D. A. Neamen (see above); Simon Sze, Physics of Semiconductor Devices (Wiley)


Physik I and II, Materialphysik I and II. The lecture will be given in English. The script will be available in English.
This course provides the fundamentals for understanding the mechanical properties of different classes of materials. The role played by the nano- and microstructure of the materials, how the mechanical properties are influenced by the composition or processing, as well as which methods can be used to determine material-specific mechanical parameters are examined.

Objective

The students are able to
- Apply the interplay of structure and properties in the selection and development of materials.
- Understand plasticity, crack growth, high temperature properties, corrosion, diffusion, environmental influences, grain growth, fatigue, fracture mechanics across material classes.
- to adjust mechanical properties in a targeted manner.
- to select and develop the optimal materials for specific application areas by understanding the temperature-dependent material properties.
- take measures to increase the service life of materials.
- to link the similarities and differences of the various classes of materials.
- understand concepts of material development and apply them to new materials.

Content

This lecture has the irreversible mechanical deformation of materials as its core topic. Independent of the material classes, the following phenomena are explained in detail and rigorously derived: Crystal plasticity at low temperatures (dislocation theory, hardening mechanisms, twinning, brittle-ductile transitions), plasticity in disordered structures (shear bands and strain localisation), Fracture mechanics (Griffith criterion, Weibull statistics, crack tip plasticity, J-integral, R-curve), fatigue (Wöhler curves and Paris law), environmental influences, tribology, high temperature plasticity (creep and deformation mechanism diagrams). All phenomena are illustrated by actual case studies using concrete materials and material systems. These include aluminium alloys, steels, high temperature alloys, advanced ceramics, structural polymers and composites. The lecture is supported by exercises and practical experiments and uses material databases.

Abstract

This course will introduce mass transport, heat conduction, charge transport, and flow in viscous liquids, with emphasis on their shared foundation in diffusive processes.

Objective

Students will learn how to create models describing transport processes. They will solve the resulting equations both analytically and numerically. They will apply these results to design materials processes and understand real-life experiments. A key takeaway will be the ability to construct simple order-of-magnitude estimates and scaling relationships that can be applied to efficient data analysis and design.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Projects and Applications

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>327-0514-00L</td>
<td>Computational Thinking Lab II</td>
<td>O</td>
<td>3</td>
<td>1G+2A</td>
<td>M. Kröger</td>
</tr>
</tbody>
</table>

Abstract
You are going to address, in groups, problems that are arising or may arise in the context of remaining courses of your studies, that cannot be solved analytically or manually within reasonable amounts of time, but solved computationally with the help of a programming language and computers. Knowledge of a computing language is required.

Objective
Participants get used to one or more collaborative tools, work actively in groups. They invent, set up, structure, plan, and attempt solving a problem that requires developing algorithms. They make use of existing, or invent novel, computational methods. Aspects that should be taken into account when developing algorithms or codes are: speed of execution, ease of use, small amount of adjustable parameters.

Content
Development of a project plan, including modules to be created, milestones to be reached, required input data and its acquisition, tests to be performed, work sharing. The project needs to be documented, and codes saved using a collaborative environment (github, vscode share). Ideally, several groups attack a similar problem so that their results can be directly compared (concerning speed of execution, algorithms, etc.)

Lecture notes
Information available at https://polyphys.mat.ethz.ch/education/courses/CTL-II.html

Literature

Prerequisites / notice
Participants need a github account and should have attended part I of this course, or attend part I in parallel. Course information available at https://polyphys.mat.ethz.ch/education/courses/CTL-II.html

327-0511-00L Capstone project

Abstract
Acquisition of independent scientific-technical skills; project management; organization and undertaking of experiments; interpretation, scientifically and technically correct project presentation in oral and written form.

Objective
Acquisition of independent scientific/technical skills; project management; organization and conducting of experiments; interpretation and scientifically/technically correct presentation of projects in oral and written form.

Content
Supervision by D-MATL research Groups. Groups of students (2 or 3 per group) each work on a research project throughout the semester.

Prerequisites / notice
Prerequisite: Successful participation in the “Praktika I - IV” (courses within the material science bachelor study at ETH) or comparable practical lab courses.
Compensatory Courses
Only possible after consultation with the Director of Studies.

Bachelor's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>327-0620-10L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>12</td>
<td>23D</td>
<td>Professors</td>
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<td>Only for Materials Science BSc Programme Regulations 2020.</td>
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</tbody>
</table>

Abstract
Independent scientific project in a D-MATL research group. A written report will be prepared on the scientific studies carried out, as well as on the evaluation and discussion of the results.

Objective
To develop the capability of independently analyzing and addressing scientific problems.

Bachelor Studies (Programme Regulations 2017)

5. Semester

Basic Courses Part 3

Self-study courses

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>327-0506-01L</td>
<td>Materials Physics II</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>P. Gambardella</td>
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<td>Only for students materials science bachelor regulations 2017.</td>
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</table>

Abstract
This course provides physical foundations to understand the response of different classes of materials to electromagnetic fields, focusing on the dielectric and optical properties of materials, and on the basic functioning of devices that exploit such properties, including photodiodes, photovoltaic cells, LEDs, and laser diodes.

Objective
This course aims at giving an understanding of physical phenomena relevant to Materials Science and, vice versa, an understanding of materials that are relevant to tailor the physical properties of electronic and optical devices.

Content
PART I: Introduction to the dielectric properties of matter
Microscopic origin of dipoles in matter; Electronic, ionic, molecular polarization. Electric field inside and outside dielectric materials. Connection between macroscopic and microscopic polarization. Dielectric breakdown.

PART II: Interaction of electromagnetic waves with matter
The EM spectrum. Electromagnetic waves in vacuum; Energy, momentum, and angular momentum of EM waves; Sources of EM radiation; EM waves in matter. The refractive index. Transmission, Reflection, and Refraction from a microscopic point of view. Optical anisotropy, Optical activity, Dichroism.

PART III: Optical Materials: Crystalline Insulators and Semiconductors, Glasses, Metals. Photonic devices: Photodiodes, Photovoltaic cells, LEDs, Laser diodes

Literature
Electromagnetism and dielectric properties: E.M. Purcell and D.J. Morin, Electricity and Magnetism (Cambridge U. Press, 2013)
Optics and optical materials: E. Hecht, Optics (Lehrmanns); M. Fox, Optical Properties of Solids (Oxford U. Press)
Photonic Devices: Simon Sze, Physics of Semiconductor Devices (Wiley)

Prerequisites / notice
Materials Physics I (327-0407-01)

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>327-0603-00L</td>
<td>Ceramics II</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>A. R. Studart</td>
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<td>Only for students materials science regulations 2017.</td>
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</table>

Abstract
Understanding of the electrical, dielectric and magnetic properties of functional ceramics for materials engineers, physicists and electrical engineers. An introduction is given to modern ceramics materials with multiple functions.

Objective
Ceramics II covers the basic principles of functional ceramics such as linear and non-linear dielectrics, semiconductors, ionic and mixed ionic-electronic conductors as well as materials aspects of high temperature superconductors. Examples of applications cover the range from piezo-, pyro and thermolectric materials over sensors and solid oxide fuel cells to superconducting magnets. At the end of the course, the students should be able to select the chemistry, design the microstructure and devise processing routes to fabricate functional ceramics for electronic, electromechanical, optical and magnetic applications.

Content
- Applications of functional ceramics - Dielectrics fundamentals & Insulators - Capacitors & resonators - Ferroelectricity & piezoelectricity - Pyroelectricity and thermolectric ceramics - Defect chemistry - Conductors - Impedance spectroscopy - Magnetic ceramics - Superconductors

Literature
Electroceramics; J.A.Moulson Free download of the book in ETH domain is possible following the link: http://www3.interscience.wiley.com/cgi-bin/booktoc/104557643
Principles of Electronic Ceramics; L.L.Hench, J.K.West

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</tr>
</thead>
<tbody>
<tr>
<td>327-0606-00L</td>
<td>Polymers II</td>
<td>O</td>
<td>3</td>
<td>2V+1U</td>
<td>T.-B. Schweizer, T. A. Tervoort</td>
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Abstract
Principles of polymer technology

Objective
To obtain an understanding of the engineering aspects of structure and properties of solid polymers. Influence of polymer processing on properties of solid polymers.

Content
Abstract
Introduction of basic concepts for composites with polymer- metal- and ceramic matrix composites; production and properties of composites reinforced with particles, whiskers, short and long fibres; selection criteria, case histories of applications, recycling, future perspectives, and basic concepts for adaptive and functional composites

Objective
Gain an insight into the diversity of opportunities to change the properties of composites, learn about the most important applications and processing techniques

Content
1. Introduction
1.1 What are advanced composites?
1.2 What are materials by combination?
1.3 Are composites an idea of today?
1.4 Delphi foresight
1.5 Why composites?
1.6 References for chapter 1

2. Basic modules
2.1 Particles
2.2 Short fibres including whiskers
2.3 Long fibres
2.4 Matrix materials
2.4.1 Polymers
2.4.2 Metals
2.4.3 Ceramics and glasses
2.5 References for chapter 2

3. PMC: Polymer Matrix Composites
3.1 Historical background
3.2 Types of PMC-laminates
3.3 Production, processing and machining operation
3.4 Mechanics of reinforcement, microstructure, interfaces
3.5 Failure criteria
3.6 Fatigue behaviour of a multiply composite
3.7 Adaptive materials systems
3.8 References for chapter 3

4. MMC: Metal matrix composites
4.1 Introduction: Definitions, selection criteria und *design*
4.2 Types von MMCs - examples und typical properties
4.3 Mechanical and physical properties of MMCs - basics of design, influencing variables and damage mechanisms
4.4 Production processes
4.5 Micro structure / interfaces
4.6 machining operations for MMC
4.7 Applications
4.8 References for chapter 4

5. CMC: Ceramic Matrix Composites
5.1 Introduction and historical background
5.2 Modes of reinforcement
5.3 Production processes
5.4 Mechanisms of reinforcement
5.5 Micro structure / interfaces
5.6 Properties
5.7 Applications
5.8 Materials testing and quality assurance
5.9 References for chapter 5

Lecture notes
The script will be delivered at the begin of the semester

Literature
The script is including a comprehensive list of references

Prerequisites / notice
Before each class, students will get a handout or they can be uploaded from the internet.
The exercises take place in small groups. It is their goal to deepen knowledge gained in the classes written end of semester examination
This course is divided into five parts:

A. Materials selection
   Principles of materials properties maps
   Introduction to the ‘Materials selector’ software package
   Case studies

B. Light metals and alloys
   Aluminium, magnesium, titanium
   Properties and hardening mechanisms
   Case studies in technological applications

C. Copper and its alloys

D. Iron and steel
   The seven pros for steel
   Fine grained steels, heat resistant steels
   Steel and corrosion phenomena
   Selection and application

E. High temperature alloys
   Superalloys: iron, nickel, cobalt
   Intermetallics: properties and application

Lecture notes
Please visit the Moodle-link for this lecture.

Literature
Gottstein, Physikalische Grundlagen der Materialkunde, Springer Verlag
Ashby/Jones, Engineering Materials 1 & 2, Pergamon Press
Ashby, Materials Selection in Mechanical Design, Pergamon Press
Porter/Easterling, Transformations in Metals and Alloys, Chapman & Hall
Bürgel, Handbuch Hochtemperatur-Werkstofftechnik, Vieweg Verlag

Prerequisites / notice
Prerequisites: Metals I

Compensatory Courses
Only possible after consultation with the Director of Studies.

Industrial Internship or Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>327-0001-00L</td>
<td>Industrial Internship</td>
<td>W</td>
<td>10 credits</td>
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<td>external organisers</td>
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<td></td>
<td>Only for Materials Science BSc.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>12 weeks of industrial internship which is completed with a written report.</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
<td></td>
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<tr>
<td>327-0002-00L</td>
<td>Project</td>
<td>W</td>
<td>10 credits</td>
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<td>Lecturers</td>
</tr>
<tr>
<td></td>
<td>Carrying out outside of D-MATL: Only possible after consultation with the Director of Studies.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Project in a research group at ETH or at an University of 12 weeks. The project is completed with a written report.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The main objective of the 12-week research project is to expose bachelor's students to the professional research environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.</td>
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</table>

Bachelor's Thesis

<table>
<thead>
<tr>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>327-0620-00L</td>
<td>Bachelor's Thesis</td>
<td>O</td>
<td>10 credits</td>
<td>17D</td>
<td>Professors</td>
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<td></td>
<td>Only for Materials Science BSc Programme Regulations 2017.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Independent scientific project in a D-MATL research group. A written report will be prepared on the scientific studies carried out, as well as on the evaluation and discussion of the results.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>To develop the capability of independently analyzing and addressing scientific problems.</td>
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</tr>
<tr>
<td>Content</td>
<td>Independent work on a scientific research project. The project will be carried out either for two days per week during the 6th semester or in a block within the first 6 weeks after the 6th semester.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The entire project, including preparation of the report, needs to take place within the allotted time.</td>
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</tbody>
</table>

Science in Perspective

Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MATL

Language Courses
see Science in Perspective: Language Courses ETH/UZH

Materials Science Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>327-0505-00L</td>
<td>Surfaces, Interfaces and their Applications I</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>N. Spencer, M. P. Heuberger, L. Isa</td>
</tr>
</tbody>
</table>

**Abstract**

After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields of tribology (friction, lubrication, and wear) and corrosion.

**Objective**

To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to choose appropriate surface-analytical approaches for solving problems.

**Content**

Introduction to Surface Science
- Physical Structure of Surfaces
- Surface Forces (static and dynamic)
- Adsorbates on Surfaces
- Surface Thermodynamics and Kinetics
- The Solid-Liquid Interface
- Electron Spectroscopy
- Vibrational Spectroscopy on Surfaces
- Scanning Probe Microscopy
- Introduction to Tribology
- Introduction to Corrosion Science

**Prerequisites / notice**

Chemistry:
- General undergraduate chemistry
- Including basic chemical kinetics and thermodynamics

**Fostered competencies**

Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Creative Thinking assessed
- Critical Thinking assessed

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>327-1201-00L</td>
<td>Transport Phenomena I</td>
<td>W Dr</td>
<td>5 credits</td>
<td>4G</td>
<td>J. Vermant</td>
</tr>
</tbody>
</table>

**Abstract**

Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

**Objective**

The teaching goals of this course are on five different levels:
1. Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling, ...
2. Ability to use the fundamental concepts in applications
3. Insight into the role of boundary conditions (mainly part 2)
4. Knowledge of a number of applications.
5. Flavor of numerical techniques: finite elements and finite differences.

**Content**

Part 1 Approach to Transport Phenomena
- Equilibrium Thermodynamics
- Balance Equations
- Forces and Fluxes
- Applications
  1. Measuring Transport Coefficients
  2. Fluid mechanics
  3. Combined heat and flow

**Literature**


**Prerequisites / notice**

Physics:
- General undergraduate physics
  - Including basic theory of diffraction and basic knowledge of crystal structures

**Fostered competencies**

Concepts and Theories assessed
- Techniques and Technologies assessed
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Creative Thinking assessed
- Critical Thinking assessed

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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-1202-00L</td>
<td>Solid State Physics and Chemistry of Materials I</td>
<td>W Dr</td>
<td>5 credits</td>
<td>4G</td>
<td>N. Spaldin</td>
</tr>
</tbody>
</table>

**Abstract**

In this course we study the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions.
Objective
Electronic properties and band theory description of conventional solids
Electron-lattice coupling and its consequences in functional materials
Electron-spin/orbit coupling and its consequences in functional materials
Structure/property relationships in strongly-correlated materials

Content
In this course we study how the properties of solids are determined from the chemistry and arrangement of the constituent atoms, with a focus on materials that are not well described by conventional band theories because their behavior is governed by strong quantum-mechanical interactions. We begin with a review of the successes of band theory in describing many properties of metals, semiconductors and insulators, and we practise building up band structures from atoms and describing the resulting properties. Then we explore classes of systems in which the coupling between the electrons and the lattice is so strong that it drives structural distortions such as Peierls instabilities, Jahn-Teller distortions, and ferroelectric transitions. Next, we move on to strong couplings between electronic charge and spin-and/or orbital- angular momentum, yielding materials with novel magnetic properties. We end with examples of the complete breakdown of single-particle band theory in so-called strongly correlated materials, which comprise for example heavy-fermion materials, frustrated magnets, materials with unusual metal-insulator transitions and the high-temperature superconductors.

Lecture notes
An electronic script for the course is provided in Moodle.

Literature
Hand-outs with additional reading will be made available during the course and posted on the moodle page accessible through MyStudies all of:
Statistical Thermodynamics (327-0315-00)
Quantenmechanik für Materialwissenschaftler/innen (327-0316-00)
Festkörpertheorie für Materialwissenschaftler/innen (327-0416-00)
Electronic, Optical and Magnetic Properties of Materials (327-0512-00)
or equivalent classes from another institution

327-1203-00L Complex Materials I: Synthesis & Assembly W Dr 5 credits 4G M. Niederberger, A. Lauria

Abstract
Introduction to materials synthesis concepts based on the assembly of differently shaped objects of varying chemical nature and length scales

Objective
The aim is a) to learn how to design and create objects as building blocks with a particular composition, size and shape, b) to understand the chemistry that allows for the creation of such hard and soft objects, and c) to master the concepts to assemble these objects into materials over several length scales.

Content
The course is divided into two parts: I) synthesis of 0-, 1-, 2-, and 3-dimensional building blocks with a length scale from nm to μm, and II) assemblies of these building blocks into 1-, 2- and 3-dimensional structures over several length scales up to cm. In part I, various methodologies for the synthesis of the building blocks will be discussed, including Turkevich and Brust-Schiffrin-method for gold nanoparticles, hot-injection for semiconducting quantum dots, aqueous and nonaqueous sol-gel chemistry for metal oxides, or gas- and liquid-phase routes to carbon nanostructures.

Part II is focused on self- and directed assembly methods that can be used to create higher order architectures from those building blocks connecting the microscopic with the macroscopic world. Examples include photonic crystals, nanocrystal solids, colloidal molecules, mesocrystals or particle-based foams and aerogels.

Prerequisites / notice
1) Materialsynthese II (327-0412-00)
2) Kristallographie (327-0104-00L), in particular structure of crystalline solids
3) Materials Characterization II (327-0413-00)

327-1204-00L Materials at Work I W Dr 4 credits 4S R. Spolenak, E. Dufresne, R. Koopmans

Abstract
This course attempts to prepare the student for a job as a materials engineer in industry. The gap between fundamental materials science and the materials engineering of products should be bridged. The focus lies on the practical application of fundamental knowledge allowing the students to experience application related materials concepts with a strong emphasis on case-study mediated learning.

Objective
Teaching goals:
- to learn how materials are selected for a specific application
- to understand how materials around us are produced and manufactured
- to understand the value chain from raw material to application
- to be exposed to state of the art technologies for processing, joining and shaping
- to be exposed to industry related materials issues and the corresponding language (terminology) and skills
- to create an impression of how a job in industry "works", to improve the perception of the demands of a job in industry

Content
This course is designed as a two semester class and the topics reflect the contents covered in both semesters.

Lectures and case studies encompass the following topics:
- Strategic Materials (where do raw materials come from, who owns them, who owns the IP and can they be substituted)
- Materials Selection (what is the optimal material (class) for a specific application)
- Materials systems (subdivisions include all classical materials classes)
- Processing
- Joining (assembly)
- Shaping
- Materials and process scaling (from nm to m and vice versa, from mg to tons)
- Sustainable materials manufacturing (cradle to cradle)
- Recycling (Energy recovery)

After a general part of materials selection, critical materials and materials and design four parts consisting of polymers, metals, ceramics and coatings will be addressed.

In the fall semester the focus is on the general part, polymers and alloy case studies in metals. The course is accompanied by hands-on analysis projects on everyday materials.

Literature
Manufacturing, Engineering & Technology
Seropo Kalpakjian, Steven Schmid
ISBN: 978-0131489653

Prerequisites / notice
- Manufacturing knowledge in Physical Metallurgy and Polymer Basics and Bachelor Level by the following lectures: Metalle 1, 2; Polymere 1, 2)
- Polymer Technology required (These subjects are covered at the Bachelor Level by the following lectures: Metalle 1, 2; Polymere 1, 2)

327-1207-00L Engineering with Soft Materials W Dr 5 credits 4G J. Vermant, L. Isa

Objective
Analysis projects on everyday materials.
In this course the engineering with soft materials is discussed. First, scaling principles to design structural and functional properties are introduced. Second, the characterisation techniques to interrogate the structure property relations are introduced, which include rheology, advanced optical microscopes, static and dynamic scattering and techniques for liquid interfaces.

The learning goals of the course are to introduce the students to soft matter and its technological applications, to see how the structure property relations depend on fundamental formulation properties and processing steps. Students should also be able to select a measurement technique to evaluate the properties.

Slides with text notes accompanying each slide are presented.

**Elective Courses**

The students are free to choose individually from the entire course offer of ETH Zurich on the Master level. Please consult the study administration in case of questions.

### EM-Practical Course in Materials Science

**Number:** 327-0702-00L  
**Title:** EM-Practical Course in Materials Science  
**Type:** W  
**ECTS:** 2 credits  
**Hours:** 4P  
**Lecturers:** K. Kunze, S. Gerstl, F. Gramm, F. Krumeich, J. Reuteler

**Abstract**

Practical work on TEM, SEM, FIB and APT treatment of typical problems. Data analysis, writing of a report.

**Objective**

Application of basic electron microscopic techniques to materials science problems.

**Prerequisites / notice**

Attendance of lecture Electron Microscopy (327-0703-00L) is recommended. Maximum number of participants 15, work in groups of 3 people.

**Literature**


Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

**Course description**

The course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

The objective is for the students to acquire a comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Content**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Lecture notes**

will be distributed in English

**Prerequisites**

Attendance of lecture Electron Microscopy (327-0703-00L) is recommended.

**Note**

Maximum number of participants 15, work in groups of 3 people.

### Electron Microscopy in Material Science

**Number:** 327-0703-00L  
**Title:** Electron Microscopy in Material Science  
**Type:** W  
**ECTS:** 4 credits  
**Hours:** 2V+2U  
**Lecturers:** S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze

**Abstract**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Objective**

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

**Content**

This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

**Prerequisites / notice**

Maximum number of participants 15, work in groups of 3 people.

**Literature**


Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

**Course description**

The course is designed to use these probes in the structural and chemical analysis of various materials.

**Content**

This course is designed to use these probes in the structural and chemical analysis of various materials.

**Lecture notes**

will be distributed in English

**Prerequisites**

No special requirements are needed for attending. Basic knowledge in chemistry and cell biology is expected.

### Biological and Bio-Inspired Materials

**Number:** 327-1221-00L  
**Title:** Biological and Bio-Inspired Materials  
**Type:** W Dr  
**ECTS:** 4 credits  
**Hours:** 3G  
**Lecturers:** A. R. Studart, I. Burgert, R. Nicolosi Libanori, G. Panzarasa

**Abstract**

The aim of this course is to impart knowledge on the underlying principles governing the design of biological materials and on strategies to fabricate synthetic model systems whose structural organization resembles those of natural materials.

**Objective**

The course offers a comprehensive introduction to evolutive aspects of materials design in nature and a general overview about the most common biopolymers and biominerals found in biological materials. Next, current approaches to fabricate bio-inspired materials are presented, followed by a detailed evaluation of their structure-property relationships with focus on mechanical, optical, surface and adaptive properties.
Content

This course is structured in 3 blocks:

Block (I): Fundamentals of engineering in biological materials
- Biological engineering principles
- Basic building blocks found in biological materials

Block (II): Replicating biological design principles in synthetic materials
- Biological and bio-inspired materials: polymer-reinforced and ceramic-toughened composites
- Lightweight biological and bio-inspired materials
- Functional biological and bio-inspired materials: surfaces, self-healing and adaptive materials

Block (III): Bio-inspired design and systems
- Mechanical actuation - plant systems
- Bio-inspiration in the built environment

Lecture notes
Copies of the slides will be made available for download before each lecture.

Literature
The course is mainly based on the books listed below. Additional references will be provided during the lectures.


Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
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</tr>
</tbody>
</table>

Abstract
Composites/hybrids are heterogeneous materials consisting of two or more bonded components, and it is possible to tailor material properties for certain applications. Typically, the components retain their structure and properties, but the properties of the composite are a combination of the properties of its components.

Objective
In this course you will get an inside to lightweight material with high strength, materials that are resistive against abrasion, ceramics with damage tolerance behavior, composites with bioactive, biodegradable, piezoresistive and -electric properties. Enables materials scientists to design composite/hybrid materials for different applications. The course will comprise a balance of lectures, exercises and laboratory classes.

Content
Introduction and basic concepts on biomedical composites and smart composites/hybrids with sensing and actuation properties; production and properties of composites reinforced with particles, whiskers, short or long fibers; selection criteria, case studies and applications, future perspectives.

1. Structural composites (polymer-, metal- and ceramic matrix composites)
   1.1. Introduction and historical background
   1.2. Components: Matrix and reinforcement materials
   1.3. Types of composites and mechanisms of reinforcement
   1.4. Production processes
   1.5. Physical and chemical properties
   1.6. Applications

2. Biomedical Composites
   2.1. Introduction and historical background
   2.2. Components: metals&alloys, natural/synthetic polymers, bioceramics
   2.3. Types of biocomposites
   2.4. Production processes
   2.5. Properties
   2.6. Applications

3. Functional Composites (Sensors and Actuators)
   3.1. Introduction and historical background
   3.2. Components: Matrix and functional filler material
   3.3. Types of composites
   3.4. Production processes
   3.5. Properties
   3.6. Applications

Lecture notes
We will work with handouts
Abstract

This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective

- Set-up, align and operate a SEM successfully and safely.
- Understand important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.
- Prepare samples with different techniques and equipment for imaging and analysis by SEM.

Content

During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications.

This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes

Lecture notes will be distributed.

Literature


Prerequisites / notice

No mandatory prerequisites.
The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

### Prerequisites / notice

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-2127-00L</td>
<td>Sustainable Materials Management: Concepts, Methods and Principles</td>
<td>W 2 credits</td>
<td>Limited number of participants. More information here: <a href="https://scopem.ethz.ch/education/MTP0.html">https://scopem.ethz.ch/education/MTP0.html</a></td>
</tr>
<tr>
<td>327-2128-00L</td>
<td>High Resolution Transmission Electron Microscopy</td>
<td>W 2 credits</td>
<td>Prior attendance to the ScopeEM TEM basic course</td>
</tr>
<tr>
<td>327-2129-00L</td>
<td>Analytical Electron Microscopy: EDS</td>
<td>W 1 credit</td>
<td>Prior attendance to ETH EM lectures (327-0703-00L Electron Microscopy in Material Science)</td>
</tr>
</tbody>
</table>

### Content

#### Lecture notes
Lecture notes will be distributed.

#### Literature

### Objective

Students develop a basic understanding of important concepts, methods and principles for sustainable materials management and become acquainted with their possibilities and limitations.

### Abstract

The aim of this course is to introduce important concepts, methods and principles for sustainable materials management and to critically reflect their possibilities and limitations. A particular focus will be laid on recycling issues.

### Topics:

1. Introduction to HRTEM and HRSTEM
2. Considerations on (S)TEM instrumentation for high resolution imaging
3. Lectures on aberrations, aberration correction and aberration corrected images
4. HRTEM and HRSTEM simulation
5. Data analysis, phase restoration and lattice-strain analysis

### Literature

### Prerequisites / notice

No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.
Abstract
The main goal of this hands-on course is to provide students with fundamental understanding of underlying physical processes, experimental set-up solutions and hands-on practical experience of analytical electron microscopy (AEM) technique for microstructure characterisation, specifically Energy Dispersive X-ray Spectroscopy (EDS) and spectrum imaging (SI) technique.

Objective
- understanding of physical processes that enable the EDS technique and data evaluation algorithms;
- hand-on experience of data acquisition and evaluation routines including
- practical understanding of different data acquisition set-ups,
- optimization of acquisition parameters for most reliable quantification of the results,
- the knowledge of the available and most reliable quantification algorithms and their handling
- the knowledge of data evaluation routines and possible handicaps for reliable elemental content distribution analyses and material composition quantification
- the effect of the specimen geometry on the data and experimental solutions for minimization of the artefacts

Content
This advanced course provides analytical EM techniques to the students with prior EM experience (TEM or SEM). At the end of the course, students will understand the physical processes that enable the EDS technique and data evaluation algorithms and apply the technique for their own research.
- Introduction to analytical electron microscopy: theory and instrumentation.
- Lectures on EDS, WDS
- Practical on EDS-SEM: data acquisition and analysis.
- Practical on EDS-TEM: data acquisition and analysis.

The hand-on trainings are to be carried-out on a real-life specimen, provided by lecturers and / by students.

Lecture notes
Provided in the course Moodle-page

Literature
- Carter & Williams: Transmission Electron Microscopy: Diffraction, Imaging and Spectrometry. Springer Verlag, 2016, DOI: 10.1007/978-3-319-26801-0

Prerequisites / notice
- Master student or PhD student who has experience with EM (SEM or TEM) techniques or prior attendance of one of the following courses: Microscopy Training SEM1 (327-2125-00L) or Microscopy Training TEM1 (327-2126-00L)
- Attendance of the following courses is of advantage, but not required: Scattering Techniques for Material Characterization (327-2137-00L) or Elements of Microscopy (227-0390-00L), or Electron Microscopy in Material Science (327-0703-00L)

327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation

Abstract
The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed. In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Objective
Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

Content
Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

327-2135-00L Advanced Analytical TEM

Abstract
Does not take place this semester.

Objective
- Setting-up the optimal operation conditions for reliable EDX analysis and quantification.
- Setting-up the optimal operation conditions for the reliable EELS analyses.
- Setting-up the optimal operation conditions for the reliable EFTEM analyses.
- EDX data acquisition, on-line analysis and quantification.
- EFTEM data acquisition and analysis.
- EELS acquisition analyses.

Content
1. Fundamentals of analytical TEM.
4. EELS.
5. EFTEM.
7. EDX. Quantification and data evaluation.
8. Demonstrations on EDX, EELS, and EFTEM data acquisitions.
9. Practical sessions for students with provided specimens. Practical sessions for students with their own specimens.
10. Questions and such: open discussion.
11. Student presentations.

Literature

Prerequisites / notice
No mandatory prerequisites. Prior attendance to EM Basic lectures (327-0703-00L, 227-0390-00L) and to the Microscopy Training TEM 1 - Introduction to TEM course (327-2126-00L) is recommended.

327-2136-00L Chemical Analysis and Spectroscopy for Energy

Abstract
This course provides an introduction to the chemical analysis and operando spectroscopy related to current scientific questions in energy research.
Objective

Objectives are the general physical concepts of physical and chemical analysis and their application on the most important questions in energy applications. Questions tackled include:
- What is/does determine selectivity / sensitivity of a technique?
- What is its spatial/temporal resolution?
- How to probe chemical reactions in action?

Content

Future as well as existing energy supply relies on the precise determination of the amount of the energy carrier either produced or spent. The devices used for this purpose range from simple amperemeter and its scientific pendant impedance spectrometer for electricity, and the chemical analysis of fuels and their combustion products. With the advent of renewable energy and its chemical or electro-chemical storage, there is increasing demand for advanced analysis tools as well as operando spectroscopy. The objective of the course is to introduce the physical basis of most commonly used methods, i.e., separation techniques (GC, MS), spectroscopic methods (impedance spectroscopy, UV-Vis-, IR-, Raman- spectroscopy), and scattering techniques (X-ray/photoelectron spectroscopy, neutron scattering) with focus on operando techniques. The methods are discussed within the framework of current scientific questions in renewable energy research such as the analysis of reaction mechanisms in thermo- and electro-catalysis and the in-situ characterisation of new energy materials with particular focus on surface phenomena and gas-solid interactions.

The course will build on the Bachelor’s degree courses Analytical Chemistry and Materials Characterization Methods.

327-2137-00L Scattering Techniques for Material Characterization W 4 credits 2V+1U T. Weber, A. Sologubenko

Abstract

The lecture presents the currently most efficient experimental techniques for microstructure material characterization: X-ray diffraction (XRD) and transmission electron microscopy (TEM). The theoretical basics, instrumentation, complementarity and exclusivity of both techniques will be taught. The course includes practical elements and examples of current research projects at D-MATL.

Objective

Students are able to do:
- systematically characterise the microstructure and phases of a given material with X-rays and electrons
- select the right tool (source, instrument, measurement strategy) and design a workflow for solving a microstructure or phase analysis problem
- describe possibilities and limitations of a given characterisation method
- comprehensively store experimentally collected data in a repository following modern data management rules such that data can be evaluated by students not involved in the experiment
- qualitatively and quantitatively evaluate and present experimental data and results collected by others

Content

The main objective of this hands-on practical course is to give students a comprehensive insight into the most important aspects of microstructure characterization using electron and X-ray scattering. The focus is on the complementarity and exclusivity of the two techniques. We will introduce the most important material characterization tasks, present the relevant physical and crystallographic fundamentals, and discuss how the tasks can be solved with electron and X-ray scattering. We will discuss intrinsic and extrinsic advantages and limitations of the methods and explain essential instrumentation requirements specific to each setup. Another essential facet of the course is the link to everyday D-MATL project problems presented by the lecturers or researchers from D-MATL. The lecture is accompanied by hands-on experiments on samples of D-MATL projects using state-of-the-art instruments.

Literature


Prerequisites / notice

Crystallography, X-ray diffraction and electron microscopy on the BSc level. All enrolled students are initially placed on the “waiting list” until the registration deadline. In the case of more than 12 applicants, the students will be selected by the lecturers before the start of the lecture according to the priority criteria: master students before doctoral students, Material Science students before students of other departments.
This course considers the multi-scale computational modeling of hard-matter systems, with an emphasis on the physical phenomena of fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers). The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

### Objective

- In this course, the students will learn:
  - Linear elastic and elastic-plastic fracture mechanics.
  - Modern computer-based techniques (using ABAQUS Finite Element Package) to simulate cracks in both bulk materials and bonded joints/interfaces.
  - Laboratory fatigue and fracture tests on details with cracks.

### Literature

- Book: Modern Numerical Methods for Engineering and Science: An Introduction to Finite Elements, by M. S. Lucas-Droste, P. Zeng
- Book: Introduction to Computational Fluid Dynamics, by E. J. Barthazy Meier, S. Handschin, B. Qureshi
- Book: Modern Computer Science: An Introduction, by A. Taras

### Prerequisites / notice

- Prior TEM experience
- Linear elastic and plastic fracture mechanics
- Modern computer-based techniques

### Content

- The fundamentals in fatigue and fracture mechanics, which are used in different engineering disciplines (e.g., for mechanical, aerospace, civil and material engineers) will be discussed. The focus will be on fundamental theories (based on fracture mechanics) that model fatigue damage and crack propagation.

### Prerequisites

- Prior experience with FIB-SEM

### Content

- Prior attendance to the ScopeM Microscopy Training TEM I: Introduction to SEM (327-2125-00L)
- Prior TEM experience

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>327-2143-00L</td>
<td>Computational Multi-Scale Modeling of Solids</td>
<td>5</td>
<td>Prior TEM experience, Prior attendance to the ScopeM Microscopy Training TEM I</td>
</tr>
<tr>
<td>327-2144-00L</td>
<td>Microscopy Training Cryogenic Electron Microscopy</td>
<td>1</td>
<td>Prior attendance to the ScopeM Microscopy Training TEM I</td>
</tr>
<tr>
<td>101-0121-00L</td>
<td>Fatigue and Fracture in Materials and Structures</td>
<td>4</td>
<td>Does not take place this semester</td>
</tr>
</tbody>
</table>
The course starts with a discussion on the importance of fatigue and fracture in different engineering disciplines such as mechanical, aerospace, civil and material engineering domains. The preliminary topics that are covered in this course are:

I) Fatigue of materials:
- Mechanisms of fatigue crack initiation in (ductile and brittle) metals.
- Crack initiation under uni-axial high-cycle fatigue (HCF) loadings: Wöhler (S-N) curves, constant life diagram approach (mean-stress effects), rainflow analysis and Miner's damage rule.
- Crack initiation under multi-axial HCF loadings: multi-axial fatigue mechanisms, critical plane approach (critical distance theory), equivalent stress approach, proportional and non-proportional loading.

II) Fracture mechanics:
- LEFM (Linear elastic fracture mechanics): limits of LEFM, stress intensity factors, crack opening displacement, mixed-mode fracture, etc.
- Elastic-plastic fracture mechanics: Irwin and Dugdale models, plastic zone shapes, crack-tip opening displacement and J-integral.
- Fatigue crack growth (FCG): FCG models, Paris' law, cyclic plastic zones, crack closure effects. This also includes FE modeling of the FCG and laboratory tests (at Empa).

III) Introduction to cohesive zone models (CZMs):
- Advantages and disadvantages of CZMs compared to fracture mechanics.
- Different bond-slip models for the bonded joints/interfaces.

IV) Computer laboratory to simulate cracks and debonding problems:
- Finite Element (FE) modeling of complex details with cracks.
- FE simulations of debonding problems using CZMs.
- Computer laboratory: FE training and exercises using (the student edition of) the ABAQUS FE Package.

V) Introduction to fatigue and fracture design in civil structures. Different methods for fatigue strengthening will be discussed.

VI) Visits to the Empa (Swiss Federal Laboratories for Materials Science and Technology) in Dübendorf, and “Laboratory Competition”. The students will:
- Visit different small-scale and large-scale fatigue testing equipment.
- Get to know different ongoing fatigue- and fracture-related projects.
- Witness and help to conduct a fatigue test on a steel plate with a pre-crack and a fracture test on an adhesively-bonded joint.
- Compare the experimental results with their own calculations (from the fracture theories).
- “Laboratory Competition” at Empa: the students with the closest predictions will win the “Empa Laboratory Competition” and will be awarded a prize.

Lecture notes
Lectures are based on the lecture slides and the handouts, which will be given to the students during the semester.

Literature

Prerequisites / notice
Note 1: A basic knowledge on mechanics of structures and structural analysis (i.e., stress-strain analysis and calculations of internal deformations, strains and stresses within structures) is recommended and will be helpful in the course.

Note 2: Laboratory demonstrations and fatigue/fracture tests at the Structural Engineering Research Laboratory of Empa in Dübendorf. This includes laboratory tours and showcasing the Empa large-scale 7-MN fatigue testing machine for bridge cables, different fatigue and fracture testing equipment for structural components, etc.

101-0617-01L Advances in Building Materials W 4 credits 2G R. J. Flatt, I. Burgert

Abstract
The course on Advances in Building Materials provides an introductory overview of the needs and future of materials science in the building sector. Focus topics concern sustainability, durability, thermal insulation, coatings, sealants, adhesives, flame retardancy and the future perspective and developments of concrete and wood with regard to smart material development and ecological concerns.

Objective
In this course, the students will gain a broad overview of the use of materials in the building sector, with a particular focus on concrete and wood. Current limitations and in particular sustainability related challenges will be detailed with the objective of laying the grounds to discuss future developments anticipated in this field.

Content
This course for civil engineers lays the grounds in the specialization Materials and Mechanics and complements the second introductory course of the specialization on Numerical Mechanics of Materials. The course also addresses master students in Materials Science and other study programs interested in deepening their understanding of application-relevant properties of engineering materials and sustainability related challenges.

The following topics are covered:
1. Material selection
2. Materials and sustainability 1
3. Materials and sustainability 2
4. Recyclability
5. Material science of wood durability
6. Material science of concrete durability
7. Foams in construction and thermal insulation
8. Sealants and adhesives in construction
9. Coatings
10. Flame retardants
11. Future of wood – 1
12. Future of wood – 2
13. Future of concrete – 1
14. Future of concrete – 2

Lecture notes
Handouts will be provided for each lecture.

101-0677-00L Concrete Technology W 2 credits 2G F. Nägele, M. Bäuml, G. Martinola, T. Wangler

Abstract
Opportunities and limitations of concrete technology. Commodities and leading edge specialties.

Objective
Advanced education in concrete technology for civil engineers who are designing, specifying and executing concrete structures.
Content

Based on the lecture 'Werkstoffe' students receive deep concrete technology training. Comprehensive knowledge of the most important properties of conventional concrete and the current areas of research in concrete technology will be presented. The course covers various topics, including:

- concrete components
- concrete properties
- concrete mix design
- production, transport, casting
- demoulding, curing and additional protective measures
- durability
- standards
- chemical admixtures
- alternative binders
- specialty concretes such as
  - self compacting concrete
  - fiber reinforced concrete
  - fast setting concrete
  - fair faced concrete
  - recycled concrete
- new research in digital fabrication with concrete

Lecture notes

Slides provided for download.

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Problem-solving

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking

151-0353-00L Mechanics of Composite Materials  W 4 credits  2V+1U  G. Pappas

Abstract
Focus is on laminated fibre reinforced polymer composites. The courses treats aspects related to micromechanics, elastic behavior of unidirectional and multidirectional laminates, failure and damage analysis, design and analysis of composite structures.

Objective
To introduce the underlying concept of composite materials and give a thorough understanding of the mechanical response of materials and structures particularly made from fiber reinforced polymer composites, including elastic behavior, failure, fracture and damage analysis as well as structural design aspects. The ultimate goal is to provide the necessary skills to address the design and analysis of modern lightweight composite structures.

Content
The course is addressing following topics:
- Introduction
- Elastic anisotropy
- Micromechanics aspects
- Classical Laminate Theory (CLT)
- Failure hypotheses and damage analysis
- Analysis and design of composite structures
- Thin ply composite shells & effects of material non-linearity

Lecture notes
Script, handouts, exercises and additional material are available in PDF-format on moodle page of the lecture.

https://moodle-app2.let.ethz.ch/course/view.php?id=2610

Literature
The lecture material is covered by a script/lecture notes compiled by CMASLab and further literature is referenced in there.

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Self-influence
Sensitivity to Diversity
Sensitivity to Diversity
Self-presentation and Self-influence

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

151-0544-00L Metal Additive Manufacturing - Mechanical Integrity and Numerical Analysis  W 4 credits  3G  E. Hosseini

Abstract
An introduction to Metal Additive Manufacturing (MAM) (e.g. different techniques, the metallurgy of common alloy-systems, existing challenges) will be given. The focus of the lecture will be on the employment of different simulation approaches to address MAM challenges and to enable exploiting the full advantage of MAM for the manufacture of structures with desired property and functionality.

Objective
The main objectives of this lecture are:
- Acknowledging the possibilities and challenges for MAM (with a particular focus on mechanical integrity aspects),
- Understanding the importance of material science and metallurgical considerations in MAM,
- Appreciating the importance of thermal, fluid, mechanical and microstructural simulations for efficient use of MAM technology,
- Using different commercial analysis tools (COMSOL, ANSYS, ABAQUS) for simulation of the MAM process.
Adaptive Materials for Structural Applications

Abstract
Adaptive materials offer appealing ways to extend the design space of structures by introducing time-variable properties into them. In this course, the physical working principles of selected adaptive materials are analyzed and simple models for describing their behavior are presented. Some applications are illustrated, also with laboratory experiments where possible.

Objective
The study of adaptive materials covers topics that range from chemical to theoretical mechanics. The objective of this course is to convey knowledge about adaptive materials, their properties, and the physical mechanisms that govern their function, so as to develop the skills to deal with this interdisciplinary subject.

Content
This course will provide the students with an insight into the properties and physical phenomena which lead to the features of adaptive materials. Starting from chemomechanical (skeletal muscles), the physical behavior of a wide range of adaptive materials, thermo- and photo-mechanical, electro-mechanical, magneto-mechanical and meta-materials will be thoroughly discussed and analyzed. Up-to-date results on their performance and their implementation in mechanical structures will be detailed and studied in laboratory sessions. Analytical tools and energy based considerations will provide the students with effective instruments for understanding adaptive materials and assess their performance when integrated in structures or when arranged in particular fashions.

Basic concepts: Power conjugated variables, dissipative effects, geometry- and materials-based energy conversion


Thermo-mechanical coupling: Shape memory alloys / polymers

Electromechanical coupling(1): DEA, EBL, electrorheological fluids

Shape control / morphing: Use, requirements, challenges

Morphing applications of variable stiffness structures: Lab work

Electromechanical coupling (2): Piezoelectric, electrostrictive effect

Vibration Reduction: Measurement, passive, semi-active (active) damping methods

Vibration reduction applications of piezoelectric materials: Lab work

Metamaterials: Definition of metamaterials - electromagnetic, acoustical and other metamaterials

Energy harvesting and sensing: Energy harvesting with EAP and piezoelectric materials, transducers as sensors: Piezo, resistive,...

Lecture notes
Lecture notes (manuscript and handouts) will be provided.
The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum

- From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.
- Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite. Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students. A visit to a solar cell or battery fab will be organized during the semester if the epidemiological situation permits.

(II) Interaction Forces on the Micro and Nano Scale

- Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.
- Self-assembly and directed assembly of 2D and 3D structures.
- The students will be introduced to the fundamental concepts of charge transport in solar cells, batteries, and electrolyzers. Emphasizing analogies between semiconductor physics and electrochemistry, this course is designed to provide a unified modern perspective of energy conversion and storage concepts for students in electrical engineering, materials science, physics, and chemistry.

Objective

- By the end of this course, the students will (1) understand the fundamentals of electronic and ionic charge transport, (2) understand the operational principles of solar cells, batteries, and electrolyzers, and (3) understand fundamental limits for each device type. In addition, the students will learn how to simulate these devices during guided exercise sessions and develop an intuitive understanding on how to interpret the most important device characteristics.

Literature

- R. Huggins, Advanced Batteries, DOI:10.1007/978-3-527-40407-4

Prerequisites / notice

- Be motivated to change the world to renewable energies! Elements of calculus will be reviewed at the beginning of the course, but we leave the hard work of solving coupled differential charge transport equations to the computer and focus on developing a strong intuition. Prior knowledge in semiconductor physics or electrochemistry is an advantage, but not a prerequisite. Students are required to bring a windows-compatible computer with a common data analysis software to the exercises. Apps for simulating devices under different operating conditions will be made available to the students. A visit to a solar cell or battery fab will be organized during the semester if the epidemiological situation permits.

Prerequisites:

- Basic knowledge of semiconductor properties.

Abstract

- The course covers the status and prospects of post-silicon memory technologies, such as PCM, RRAM, STT-MRAM and FeRAM, and others. Students will learn and compare these future memory technologies by means of interactive lectures, group projects, and laboratory sessions. The course employs constructive alignment and active learning teaching concepts.

Objective

- Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCRAM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict them at least niche applications for ever-growing hardware market. However, some of these technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now.

Literature

- M. Yarema, R. Carron, Lecture reprints (in english).
Abstract

Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers.

Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manmade and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the-art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.

Lecture notes

All the enrolled students will get access to a password protected website where they can find pdf files of the lecture notes, and typically 1-2 journal articles per lecture that cover selected topics.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Type</th>
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</tr>
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<tbody>
<tr>
<td>376-1714-00L</td>
<td>Biocompatible Materials</td>
<td>W</td>
<td>4 credits</td>
<td>S. Schön, M. Rottmar, M. Zenobi-Wong</td>
</tr>
<tr>
<td>402-0317-00L</td>
<td>Semiconductor Materials: Fundamentals and Fabrication</td>
<td>W</td>
<td>6 credits</td>
<td>S. Schön. W. Wegscheider</td>
</tr>
<tr>
<td>402-0468-15L</td>
<td>Nanomaterials for Photonics</td>
<td>W</td>
<td>6 credits</td>
<td>R. Grange</td>
</tr>
</tbody>
</table>

**Literature**


(available online via ETH library)

Handouts are deposited online (moodle).

**Lecture notes**

Handouts references therein.
Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties, and the state-of-the-art applications.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based,...) and their uses as building blocks for advanced applications in photonic systems (optoelectronics, plasmonics, photonic crystal,...). Together with the exercises, the students will learn (1) to read, summarize, and discuss scientific articles related to the lecture, (2) to estimate orders of magnitude with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.

Content
1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

402-0535-00L Introduction to Magnetism
W 6 credits 3G A. Vindigni

Abstract
Atomic paramagnetism and diamagnetism, itinerant and local-moment interatomic coupling, magnetic order at finite temperature, spin precession, approach to equilibrium through thermal and quantum dynamics, dipolar interaction in solids.

Objective
- Apply concepts of quantum-mechanics to estimate the strength of atomic magnetic moments and their interactions
- Identify the mechanisms from which exchange interaction originates in solids (itinerant and local-moment magnetism)
- Evaluate the consequences of the interplay between competing interactions and thermal energy
- Apply general concepts of statistical physics to determine the origin of bistability in realistic magnets
- Discriminate the dynamic responses of a magnet to different external stimuli

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1701 of 2416
Introduction to Computer Simulation Methods for Physics Problems

The lecture "Introduction to Magnetism" is a regular course of the Physics MSc program and aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what "being magnetic" means is essential to address this question properly. Theoretical concepts will be applied to few selected nano-sized magnets, which will serve as clean reference systems.

At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Preliminary contents for the HS21:
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field).
- Spin resonance and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)
- Magnetic order at finite temperatures (Ising and Heisenberg models, low-dimensional magnetism)
- Dipolar interaction in solids (shape anisotropy, dipolar frustration, origin of magnetic domains)

Learning material will be made available through a dedicated RStudioServer and through Moodle.

Assessed

Literature recommendations and references are included in the lecture notes.

402-0595-00L Semiconductor Nanostructures

Abstract

The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

Objective

At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

402-0809-00L Introduction to Computational Physics

Abstract

This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

Objective

Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Content

Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Lecture notes and slides are available online and will be distributed if desired.

459-0659-00L Electrochemistry: Fundamentals, Cells & Applications

Abstract

The lecture Electrochemistry deals with the basic principles of electrochemistry and encompasses the following topics:
- Electrode processes and electrode potentials
- Electrode reactions and their kinetics
- Battery and fuel cell technology
- Electroanalytical methods
- Electrochemical sensors

Objective

At the end of the lecture the student should understand the basic principles of electrochemistry and be able to apply them to practical problems.

Content

The course is designed to provide a comprehensive understanding of the fundamentals of electrode processes and electrode potentials. The following topics will be covered:
1. Electrode reactions and their kinetics
2. Battery and fuel cell technology
3. Electroanalytical methods
4. Electrochemical sensors

Lecture notes and slides are available online and will be distributed if desired.

Literature

Lecture notes and slides are available online and will be distributed if desired.

Prerequisites / notice

Students are assumed to possess a basic knowledge about quantum mechanics, solid-state and statistical physics as well as classical electromagneticism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.
The course establishes the fundamentals to understand and describe electrochemical reactions and phenomena related to these. The students are familiarized with key concepts and approaches in electrochemistry and selected aspects of materials science and engineering and how they are to be used in selected applications. In this course, the students will explore the quite new topic of biomolecular condensates. Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of polysaccharides, and emulsifiers. Mixtures of such raw material determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food. The aggregation of food material determines the appearance and performance of complex food systems as well as nutritional aspects. The underlying colloidal laws reflect the structure of the individual raw material (length scale, time scale, and interacting forces). Once these concepts are appreciated the aggregation of most food systems falls into recognizable patterns that can be used to modify and structure food or to design new products. The application and use of these concepts are discussed in light of common food production.

**Abstract**

Introduction to electrochemistry from a physical chemistry point of view, focusing on thermodynamics & kinetics of electrochemical reactions, and engineering aspects of electrochemical cells. The topics are of generic nature yet also discussed in the context of specific applications in industrial electrochemistry, energy storage and conversion, electroanalytical techniques, sensors and corrosion.

**Objective**

- Chapter I - Redox reactions, Faraday's laws;
- Chapter II - Equilibrium electrochemistry:
cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces:
electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes:
conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry:
overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry:
electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion:
important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors:
potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion:
corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

**Prerequisites / notice**

Students should be familiar with the fundamentals of physical chemistry.

**Literature**


**Lecture notes**

Lecture notes, exercise & solutions (PDF files) via download website

**Content**

The first lecture will serve to form groups of students and assign papers.

**Objective**

- Chapter I - Redox reactions, Faraday's laws;
- Chapter II - Equilibrium electrochemistry:
cells, galvanic and electrolytic cells, thermodynamic state functions, theoretical cell voltage, half-cell / electrode potential, hydrogen electrode, the electrochemical series, Nernst equation;
- Chapter III - Electrodes & interfaces:
electrochemical potential, phase potentials, work function, Fermi level, the electrified interface, the electrochemical double layer, reference electrodes and laboratory cells;
- Chapter IV - Electrolytes:
conductivity, aqueous electrolytes, transference effects, liquid junctions, polymer electrolytes, ion-exchange membranes, Donnan exclusion, solid state ion conductors;
- Chapter V - Dynamic electrochemistry:
overpotentials, description of charge-transfer reaction, Butler-Volmer and Tafel equation, exchange current density, mass transport limitations;
- Chapter VI - Industrial electrochemistry:
electrochemical engineering, process and reactor types, current density distribution, porous electrodes, chlor-alkali and HCl electrolysis, oxygen depolarized cathode;
- Chapter VII - Energy storage & conversion:
important primary and secondary battery chemistries, fuel cells, polymer electrolyte fuel cells, low temperature H2 and O2 electrochemistry, electrocatalysis, triple-phase boundary, solid oxide fuel cell, conversion efficiency;
- Chapter VIII - Electroanalytical methods & sensors:
potentiometry, amperometry, cyclic and stripping voltammetry, rotating disc electrode studies, electrochemical sensors;
- Chapter IX - Corrosion:
corrosion reactions, Pourbaix diagram, corrosion potential, passivation, corrosion protection

**Prerequisites / notice**

Students should be familiar with the fundamentals of physical chemistry.

**Literature**


**Lecture notes**

Lecture notes, exercise & solutions (PDF files) via download website

**Content**

In Physics of Food Colloids the principles of colloid science will be applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw materials determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

**Objective**

In Physics of Food Colloids the principles of colloid science will be applied to the aggregation of food materials based on proteins, polysaccharides, and emulsifiers. Mixtures of such raw materials determine the appearance and performance of our daily food. In a number of examples, colloidal laws are linked to food science and the manufacturing and processing of food.

**Content**

Lectures include interfacial tension (4h), protein aggregation in bulk and interfaces (4h), Pickering emulsions (2h), gels (2h), aggregation of complex mixtures (4h), and the use of light scattering in investigating complex food structures (8h). Most chapters include some hand-ons examples of the gain knowledge to common food products.

**Literature**

Provided in the lecture notes.

**Abstract**

In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

**Objective**

In this course, the students will explore the quite new topic of biomolecular condensates. Concepts and tools from biology, chemistry, biophysics and soft materials will be used, on one hand, to develop an understanding of the biological properties and functions of biomolecular condensates in health and disease, while, on the other, to inspire new materials.

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**Literature**

Provided in the lecture notes.
In terms of content, you, the student, after a general introduction to the topic, will learn about milestone works and current research questions in the young field of biomolecular condensates (properties, functions and applications) from an interdisciplinary point of view in a course which is a combination of literature (presentations given by pairs of students with different scientific backgrounds) and research seminars (presentations given by the lecturers all active experts in the field, with different backgrounds and expertise).

As to the skills, you will have the opportunity to learn how to critically read and evaluate scientific literature, how to give scientific presentations to an interdisciplinary audience (each presentation consisting of an introduction, critical description of the results and discussion of their significance) and substantiate your statements, acquire a critical mindset (pros/cons of chosen approaches/methods and limitations, quality of the data, solidity of the conclusions, possible follow-up experiments) that allows you to ask relevant questions and actively participate to the discussion.

With the final presentation you will have the unique opportunity to interact closely with the interdisciplinary group of lecturers (all internationally well-established experts) who will guide you in the choice of a subtopic and related literature.

Each week the lecture will consist of:
1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
2) a research seminar: the presentation of the milestone literature will serve as the introduction to the lecture by one of the lecturers of the course on their own state-of-the-art research in the field.

For the final examination, the students will be helped by the lecturers in identifying a research topic and related literature.

The topic of biomolecular condensates goes beyond the boundaries of traditional disciplines and needs a multi-pronged approach that leverages on, and cross-fertilizes, biology, physical chemistry, biophysics and soft materials to develop a proper understanding of the properties, functions in health and disease (Alzheimer’s, Parkinson’s, etc.), as well as possible applications of these biomolecular condensates.

The milestone papers will be provided in advance.

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1) a short literature seminar: Pairs of students from different scientific backgrounds will be formed and assigned beforehand to present milestone literature to the class and facilitate the ensuing discussion. In the first class the pairs will be formed, the milestone papers made known to the whole class and assigned to the pairs.
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### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Materials Science Master - Key for Type</th>
<th>Z</th>
<th>Courses outside the curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Dr</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>O</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key for Hours</th>
<th>P</th>
<th>practical laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>A</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>D</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>R</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
</tr>
</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Mathematics (General Courses)

#### Generally Accessible Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>R. Abgrall, M. Iacobelli, A. Bandeira, A. Iozzi, S. Mishra, R. Pandharipande, University lecturers</td>
</tr>
<tr>
<td>401-5960-00L</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>N. Hungerbühler, M. Akved, D. Grawehr Morath, J. Hromkovic, P. Spindler</td>
</tr>
</tbody>
</table>

#### Abstract

Didactics colloquium

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### Actuary SAA Education at ETH Zurich

Further pieces of information are available at Prof. M. Wüthrich's secretariat, HG F 42.

#### Number       | Title                                                      | Type | ECTS | Hours  | Lecturers                                                                 |
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>401-3925-00L</td>
<td>Non-Life Insurance: Mathematics and Statistics</td>
<td>W</td>
<td>8</td>
<td>4V+1U</td>
<td>M. V. Wüthrich</td>
</tr>
</tbody>
</table>

#### Abstract

The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffication with generalized linear models and neural networks, credibility theory, claims reserving and solvency.

#### Objective

The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.

#### Content

- Collective Risk Modeling
- Individual Claim Size Modeling
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tariffication
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

#### Lecture notes

M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics

http://ssrn.com/abstract=2319328

#### Literature

M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications

http://ssrn.com/abstract=3822407

#### Prerequisites / notice

The exams ONLY take place during the official ETH examination period (no semester end exams), and only in person exams (i.e. no remote exams).

This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

#### Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

#### Fostered competencies

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management

#### 401-3922-00L

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Insurance Mathematics</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>M. Koller</td>
</tr>
</tbody>
</table>

#### Abstract

The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

#### 401-3929-00L

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Risk Management in Social and Pension Insurance</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>P. Blum</td>
</tr>
</tbody>
</table>

#### Abstract

Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. We study short-term and long-term financial risk and its interplay with other risk factors, and we develop methods for the measurement and management of financial risk and return in an asset/liability context with the goal of assuring sustainable funding.
For pension insurance and other forms of social insurance, investment returns are an important source of funding. In order to earn these returns, substantial financial risks must be taken, and these risks represent an important threat to financial stability, in the long term and in the short term.

Objective

Understand the basic asset-liability framework: essential principles and properties of social and pension insurance; cash flow matching, duration matching, valuation portfolio and loose coupling; the notion of financial risk; long-term vs. short-term risk; coherent measures of risk.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Understand the conditions for sustainable funding: derivation of required returns; interplay between return levels, contribution levels and other parameters; influence of guaranteed benefits.

Understand the notion of risk-taking capability: capital process as a random walk; measures of long-term risk and relation to capital; short-term solvency vs. long-term stability; effect of embedded options and guarantees; interplay between required return and risk-taking capability.

Be able to study empirical properties of financial assets: the Normal hypothesis and the deviations from it; statistical tools for investigating relevant risk and return properties of financial assets; time aggregation properties; be able to conduct analysis of real data for the most important asset classes.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Content

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of:

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

This course counts towards the diploma of “Aktuar SAV”.

The exams ONLY take place during the official ETH examination period.

401-3928-00L Reinsurance Analytics W 4 credits 2V
Does not take place this semester.

Abstract

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Objective

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds

Lecture notes

Prerequisites / notice

401-3928-00L Reinsurance Analytics W 4 credits 2V
Does not take place this semester.
In life insurance, it is essential to have adequate mortality tables, be it for reserving or pricing purposes. The course provides the tools to create mortality tables on their own. The exams ONLY take place during the official ETH examination period. The course counts towards the diploma of "Aktuar SAV".

### Content

**Mathematical Modelling in Life Insurance**

- *401-3927-00L*
- **Objective**: The course's objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn to price embedded options in life insurance. Aside of the mere application of specific models, they should develop an intuition for the various drivers of the value of these options.
- **Content**: Following main topics are covered:
  1. Guarantees and options embedded in life insurance products.
  - Stochastic valuation of participating contracts
  - Stochastic valuation of Unit Linked contracts
  2. Mortality Tables:
  - Determining raw mortality rates
  - Smoothing techniques: Whittaker-Henderson, smoothing splines, ...
  - Trends in mortality rates
  - Stochastic mortality model due to Lee and Carter
  - Neural Network extension of the Lee-Carter model
  - Integration of safety margins

### Prerequisites / notice

**Fostered competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Personal Competencies: Adaptability and Flexibility, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

**Lecture notes**

Lectures notes and slides will be provided.

### Prerequisites / notice

**Basic knowledge in statistics, probability theory, and actuarial techniques**

**An excerpt of last year's lecture notes is available here**: [https://sites.google.com/site/philipparbenz/reinsuranceanalytics](https://sites.google.com/site/philipparbenz/reinsuranceanalytics)

### 401-3913-01L Mathematical Foundations for Finance

**Abstract**

First introduction to main modelling ideas and mathematical tools from mathematical finance.

**Objective**

This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

**Content**

- Financial market models in finite discrete time
- Absence of arbitrage and martingale measures
- Valuation and hedging in complete markets
- Basics about Brownian motion
- Stochastic integration
- Stochastic calculus: Ito's formula, Girsanov transformation, Ito's representation theorem
- Black-Scholes formula
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems. This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.


This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Content
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature
Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume1;

Further readings:

References will be given on a topic-by-topic basis during the course.

Fostered competencies
Subject-specific Competencies

Method-specific Competencies

Personal Competencies

Concepts and Theories assessed
Analytical Competencies assessed
Problem-solving assessed
Critical Thinking assessed

Mathematics (General Courses) - Key for Type

<table>
<thead>
<tr>
<th>Z</th>
<th>Courses outside the curriculum</th>
<th>W+</th>
<th>Eligible for credits and recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

Key for Hours

| V  | lecture                        | P  | practical/laboratory course        |
| G  | lecture with exercise          | A  | independent project                |
| U  | exercise                       | D  | diploma thesis                     |
| S  | seminar                        | R  | revision course / private study    |
| K  | colloquium                     |    |                                     |

ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Mathematics Bachelor

#### Bachelor Studies (Programme Regulations 2021)

#### First Year Compulsory Courses

##### First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10 credits</td>
<td>6V+3U</td>
<td>G. Felder</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.</td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>The ability to work with the basics of calculus in a mathematically rigorous way.</td>
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</tr>
<tr>
<td></td>
<td><strong>Literature</strong></td>
<td></td>
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</tr>
</tbody>
</table>

| 402-1701-00L | Physics I | O    | 7 credits | 4V+2U   | W. Wegscheider |
|        | **Abstract**                        |      |           |         |                 |
|        | This course gives a first introduction to Physics with an emphasis on classical mechanics. |
|        | **Objective**                       |      |           |         |                 |
|        | Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems. |

| 252-0847-00L | Computer Science | O    | 5 credits | 2V+2U   | C. Cotrini Jimenez, F. O. Friedrich Wicker |
|        | **Abstract**                        |      |           |         |                 |
|        | The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required. |
|        | **Objective**                       |      |           |         |                 |
|        | Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist. |
|        | **Content**                          |      |           |         |                 |
|        | The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications. |
|        | **Lecture notes**                   |      |           |         |                 |
|        | English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online. |
|        | **Literature**                      |      |           |         |                 |
|        | Bjørn Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010 |
|        | Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000 |

### First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>P. Biran, M. Einsiedler</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>Objective</strong></td>
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</tr>
<tr>
<td></td>
<td>- Mastering basic concepts of Linear Algebra</td>
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<tr>
<td></td>
<td>- Introduction to mathematical methods</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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</tr>
<tr>
<td></td>
<td>- Basics</td>
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<tr>
<td></td>
<td>- Vectorspaces and linear maps</td>
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<tr>
<td></td>
<td>- Systems of linear equations and matrices</td>
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<tr>
<td></td>
<td>- Determinants</td>
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<tr>
<td></td>
<td>- Endomorphisms and eigenvalues</td>
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<tr>
<td></td>
<td><strong>Lecture notes</strong></td>
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<tr>
<td></td>
<td>We will provide German lecture notes and an English translation at latest at the start of the semester.</td>
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</tbody>
</table>

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Autumn Semester 2022

Page 1711 of 2416
Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester. Besides this we also recommend:

In addition we recommend this general introduction into studying mathematics:

### Compulsory Courses

#### Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>E. Kowalski</td>
</tr>
</tbody>
</table>

**Abstract**
Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.

**Objective**
Working knowledge of functions of one complex variables; in particular applications of the residue theorem.

**Literature**
- Th. Gamelin: Funktionentheorie. Springer Verlag
- D. Salamon: "Funktionentheorie". Birkhauser, 2011. (In German)

| 401-2003-00L | Algebra I              | O    | 7    | 3V+2U | R. Pink |

**Abstract**
Introduction and development of some basic algebraic structures - groups, rings, fields.

**Objective**
Introduction to basic notions and results of group, ring and field theory.

**Content**
- Group Theory: basic notions and examples of groups, subgroups, factor groups, homomorphisms, group actions, Sylow theorems, applications
- Ring Theory: basic notions and examples of rings, ring homomorphisms, ideals, factor rings, euclidean rings, principal ideal domains, factorial rings, applications
- Field Theory: basic notions and examples of fields, field extensions, algebraic extensions, applications

**Literature**
- Karpfinger-Meyberg: Algebra, Spektrum Verlag
- S. Bosch: Algebra, Springer Verlag
- B.L. van der Waerden: Algebra I und II, Springer Verlag
- S. Lang, Algebra, Springer Verlag
- A. Knapp: Basic Algebra, Springer Verlag
- J.F. Humphreys: A Course in Group Theory (Oxford University Press)
- G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)
- M. Artin: Algebra (Birkhaeuser Verlag)

| 401-2653-21L | Numerical Analysis I   | O    | 7    | 3V+2U | C. Schwab |

**Abstract**
This course will give an introduction to mathematical analysis of numerical methods, aimed at mathematics majors. It covers numerical linear algebra, quadrature, interpolation and approximation methods as well as their error analysis and implementation.

**Objective**
Knowledge of the fundamental numerical methods, their mathematical foundation as well as 'numerical literacy': application of numerical methods for the solution of application problems, mathematical foundations of numerical methods, and basic mathematical methods of the analysis of stability, consistency and convergence of numerical methods, MATLAB implementation.

**Content**
- Rounding errors, direct solution of linear systems of equations, iterative solution of systems of nonlinear equations, interpolation and approximation (polynomial as well as trigonometric), least squares problems, extrapolation, numerical quadrature, elementary optimization methods, fast Fourier transformation.

**Lecture notes**
Lecture Notes and reading list will be available.

**Literature**
- Quarteroni, Sacco and Salieri, Numerische Mathematik 1 + 2, Springer Verlag 2002 (in German).

There is an English version of this text, containing both German volumes, from the same publisher. If you feel more comfortable with English, you can follow this text as well. Content and Indexing are identical in the German and the English text.
Admission Requirements:
Completed courses and passed written exams
Linear Algebra I, Analysis I in ETH BSc MATH
Linear Algebra II, Analysis II in ETH BSc MATH

Weekly homework assignments involving MATLAB programming are an integral part of the course.
Turn-in of solutions will be graded.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2283-00L</td>
<td>Analysis III (Measure Theory)</td>
<td>O</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>F. Da Lio</td>
</tr>
</tbody>
</table>

Abstract
Measure and integration theory, including: Carathéodory's theorem, Lebesgue measure, Radon measure, Hausdorff measure, convergence theorems, L\(^p\) spaces, Radon-Nikodym theorem, product measure and Fubini's theorem

Objective
Basics of abstract measure and integration theory

Content
- Measure Spaces (Lebesgue Measure, Hausdorff Measure, Radon Measure)
  - Measurable Functions: definition and properties
  - Integration: definition, properties, theorems of convergence, Lebesgue L\(^p\) spaces
  - Product Measures and Multiple Integrals. Fubini and Tonelli Theorems, Convolutions
  - Differentiation of measures (if time permits)

Lecture notes
Die Vorlesung folgt dem Skript von der Dozentin
(https://people.math.ethz.ch/~fdalio/Measuremainfile.pdf)

Literature
1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy "Measure theory and fine properties of functions"
3. Walter Rudin "Real and complex analysis"
4. R. Bartle The elements of Integration and Lebesgue Measure
   http://www.mat.uniroma2.it/~cannarsa/cam_0607.pdf

Prerequisites / notice
Analysis 1 & 2 und basic notions of topology

Minor Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>W</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>Y. Chu</td>
</tr>
</tbody>
</table>

Abstract
Introductory course on quantum and atomic physics including optics and statistical physics.

Objective
A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.

Content
Einführung in die Quantenphysik: Planck'sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrsche Atommodell, de-Broglie Materiewellen.

Optik-Wellenoptik: Linsen, Abbildungssysteme, Brechung und Fermatsches Prinzip, Beugung, Interferenz, Fabry-Perot, Interferometer, Spektrometer.

Quantenmechanik: Dualismus Teilchen-Welle, Wellenfunktionen, Operatoren, Schrödinger-Gleichung, Potentialstufe und Potentialkasten, harmonischer Oszillator


Lecture notes
Im Rahmen der Veranstaltung werden die Folien in elektronischer Form zur Verfügung gestellt. Ergänzendes Buch wird als Pflichtlektüre empfohlen. Es wird kein Skript in der Vorlesung verteilt.
Wir werden die Quantenmechanik anhand der Schrödinger-Gleichung mit den klassischen elektro-magnetischen Wellen vergleichen. Zu den klassischen Wellen werden Ergänzungsunterlagen verteilt.

Literature
M. Alonso, E. J. Finn
Quantengyakis und Statistische Physik
R. Oldenbourg Verlag, München
5. Auflage
ISBN 978-3-486-71340-4

402-2203-01L
Classical Mechanics
W 7 credits 4V+2U M. Gaberdiel
Abstract
A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.
Objective
Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

252-0057-00L
Theoretical Computer Science
W 7 credits 4V+2U J. Hromkovic, H.-J. Böckenhauer, D. Komm
Abstract
Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be useful? d) What is nondeterminism and what role does it play in CS? e) How to represent infinite objects by finite automata and grammars?
Objective
Learning the basic concepts of computer science along their historical development
Content
This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:
- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

Lecture notes
The lecture is covered in detail by the textbook "Theoretical Computer Science".

Literature
Basic literature:

Further reading:

More exercises and examples in:
6. A. Asteroth, Ch. Baier: Theoretische Informatik

Prerequisites / notice
During the semester, two non-obligatory test exams will be offered.

227-0045-00L
Signals and Systems I
W 4 credits 2V+2U H. Bölcskei
Abstract
Objective
Introduction to mathematical signal processing and system theory.
Content

Lecture notes
Lecture notes, problem set with solutions.

Compulsory Elective Courses
no course offering in this semester

Bachelor Studies (Programme Regulations 2016)

Compulsory Courses

Examination Block I
In Examination Block I either the course unit 402-2883-00L Physics III or the course unit 402-2203-01L Classical Mechanics must be chosen and registered for an examination. (Students may also enrol for the other of the two course units; within the ETH Bachelor's programme in mathematics, this other course unit cannot be registered in myStudies for an examination nor can it be recognised for the Bachelor's degree.)

For 252-0851-00L Algorithms and Complexity, see http://www.vvz.ethz.ch/Vorlesungsverzeichnis/lerneinheit.view?lang=en&lerneinheitId=147860&semkez=2021W&ansicht=LEHRVERANSTALTUNGEN &

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6</td>
<td>3+2V</td>
<td>E. Kowalski</td>
</tr>
</tbody>
</table>
Abstract
Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.
Objective
Working knowledge of functions of one complex variables; in particular applications of the residue theorem.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1714 of 2416
Literature


Th. Gamelin: Complex Analysis. Springer 2001


D. Salamon: "Funktionentheorie". Birkhauser, 2011. (In German)


K. Jaenich: Funktionentheorie. Springer Verlag

R. Remmert: Funktionentheorie I. Springer Verlag

E. Hille: Analytic Function Theory. AMS Chelsea Publications

<table>
<thead>
<tr>
<th>401-2333-00L</th>
<th>Mathematical Methods of Physics I</th>
<th>O</th>
<th>6 credits</th>
<th>3V+2U</th>
<th>T. H. Willwacher</th>
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</table>

<table>
<thead>
<tr>
<th>402-2883-00L</th>
<th>Physics III</th>
<th>W</th>
<th>7 credits</th>
<th>4V+2U</th>
<th>Y. Chu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Introductory course on quantum and atomic physics including optics and statistical physics.</td>
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<tr>
<td>Objective</td>
<td>A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.</td>
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<tr>
<td>Content</td>
<td>Einführung in die Quantenphysik: Planck'sche Strahlung (Wärmestrahlung), Photonen, Photoelektrischer Effekt, Thomson und Rutherford Streuung, Compton Streuung, Bohrsche Atommodell, de-Broglie Materiewellen.</td>
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<table>
<thead>
<tr>
<th>402-2203-01L</th>
<th>Classical Mechanics</th>
<th>W</th>
<th>7 credits</th>
<th>4V+2U</th>
<th>M. Gaberdiel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.</td>
<td></td>
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</tbody>
</table>

**Examination Block II**

Students who have not yet tried the Examination Block 2 (Regulations 2016) can choose to take 401-2283-00L Analysis III (Measure Theory) instead of 401-2284-00L Measure and Integration. To register for 401-2283-00L Analysis III (Measure Theory), please contact exams@ethz.ch. In case of a repetition of the Examination Block 2, the same course as in the first try will be examined.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2003-00L</td>
<td>Algebra I</td>
<td>O</td>
<td>7</td>
<td>3V+2U</td>
<td>R. Pink</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction and developement of some basic algebraic structures - groups, rings, fields.</td>
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</tr>
<tr>
<td>Objective</td>
<td>Introduction to basic notions and results of group, ring and field theory.</td>
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<td></td>
</tr>
<tr>
<td>Content</td>
<td>Group Theory: basic notions and examples of groups, subgroups, factor groups, homomorphisms, group actions, Sylow theorems, applications</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Ring Theory: basic notions and examples of rings, ring homomorphisms, ideals, factor rings, euclidean rings, principal ideal domains, factorial rings, applications</td>
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<tr>
<td></td>
<td>Field Theory: basic notions and examples of fields, field extensions, algebraic extensions, applications</td>
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<td></td>
</tr>
</tbody>
</table>
Literature

Karpfinger-Meyberg: Algebra, Spektrum Verlag
S. Bosch: Algebra, Springer Verlag
B.L. van der Waerden: Algebra I und II, Springer Verlag
S. Lang, Algebra, Springer Verlag
A. Knapp: Basic Algebra, Springer Verlag
J. Rotman, "Advanced modern algebra, 3rd edition, part 1"
http://bookstore.ams.org/gsm-165/
J.F. Humphreys: A Course in Group Theory (Oxford University Press)
G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)
M. Artin: Algebra (Birkhaeuser Verlag)

Analysis III (Measure Theory)

<table>
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<tr>
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<tr>
<td>401-2283-00L</td>
<td>Analysis III (Measure Theory)</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>F. Da Lio</td>
</tr>
</tbody>
</table>

Abstract
Measure and integration theory, including: Caratheodory's theorem, Lebesgue measure, Radon measure, Hausdorff measure, convergence theorems, $L^p$ spaces, Radon-Nikodym theorem, product measure and Fubini's theorem

Objective
Basics of abstract measure and integration theory

Content
Measure Spaces (Lebesgue Measure, Hausdorff Measure, Radon Measure)
• Measurable Functions: definition and properties
• Integration: definition, properties, theorems of convergence, Lebesgue $L^p$ spaces
• Product Measures and Multiple Integrals. Fubini and Tonelli Theorems, Convolutions
• Differentiation of measures (if time permits)

Lecture notes
Die Vorlesung folgt dem Skript von der Dozentin
(https://people.math.ethz.ch/~fdalio/Measuremainfile.pdf)

Literature
1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy "Measure theory and fine properties of functions"
3. Walter Rudin "Real and complex analysis"
4. R. Bartle The elements of Integration and Lebesgue Measure
http://www.mat.uniroma2.it/~cannarsa/cam_0607.pdf

Prerequisites / notice
Analysis 1 & 2 und basic notions of topology

Minor Courses

Core Courses (Programme Regulations 2016)

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>402-0351-00L</td>
<td>Astronomy</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>H. M. Schmid, A. M. Glauser</td>
</tr>
</tbody>
</table>

Abstract
An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology

Objective
This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.

Content
Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie.

Lecture notes
Kopien der Präsentationen werden zur Verfügung gestellt.

Literature
Der Neue Kosmos. A. Unsöld, B. Baschek, Springer

Oder sonstige Grundlehrbücher zur Astronomie.

Core Courses (Programme Regulations 2016)

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<tr>
<td>252-0057-00L</td>
<td>Theoretical Computer Science</td>
<td>W</td>
<td>7</td>
<td>4V+2U</td>
<td>J. Hromkovic, H.-J. Böckenhuber, D. Komm</td>
</tr>
</tbody>
</table>

Abstract
Concepts to cope with: a) what can be accomplished in a fully automated fashion (algorithmically solvable) b) How to measure the inherent difficulty of tasks (problems) c) What is randomness and how can it be useful? d) What is nondeterminism and what role does it play in CS? e) How to represent infinite objects by finite automata and grammars?

Objective
Learning the basic concepts of computer science along their historical development

Content
This lecture gives an introduction to theoretical computer science, presenting the basic concepts and methods of computer science in its historical context. We present computer science as an interdisciplinary science which, on the one hand, investigates the border between the possible and the impossible and the quantitative laws of information processing, and, on the other hand, designs, analyzes, verifies, and implements computer systems.

The main topics of the lecture are:
- alphabets, words, languages, measuring the information content of words, representation of algorithmic tasks
- finite automata, regular and context-free grammars
- Turing machines and computability
- complexity theory and NP-completeness
- design of algorithms for hard problems

Lecture notes
The lecture is covered in detail by the textbook "Theoretical Computer Science".
Literature

Basic literature:


Further reading:


More exercises and examples in:

6. A. Asteroth, Ch. Baier: Theoretische Informatik

Prerequisites / notice

During the semester, two non-obligatory test exams will be offered.

Core Courses

Core Courses: Pure Mathematics

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<tr>
<td>401-3531-00L</td>
<td>Differential Geometry I</td>
<td>W</td>
<td>10 credits</td>
<td>4V+1U</td>
<td>J. Serra</td>
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<td>401-3461-00L</td>
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<tr>
<td>401-3601-00L</td>
<td>Probability Theory</td>
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</table>

Abstract

Introduction to differential geometry and differential topology. Contents: Curves, (hyper-)surfaces in R^n, geodesics, curvature, Theorema Egregium, Theorem of Gauss-Bonnet. Hyperbolic space. Differentiable manifolds, immersions and embeddings, Sard’s Theorem, mapping degree and intersection number, vector bundles, vector fields and flows, differential forms, Stokes’ Theorem.

Objective

Introduce the classical theory of curves and surfaces (which is the precursor of modern Riemannian geometry). Invite students to use and sharpen their geometric intuition. Introduce the language, basic tools, and some fundamental results in modern differential geometry.

Lecture notes

Partial lecture notes are available from Prof. Lang's website https://people.math.ethz.ch/~lang/

Literature

- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- John M. Lee: Introduction to Smooth Manifolds
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnel: Differentialgeometrie, Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Core Courses: Pure Mathematics (Mathematics Master)

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<td>P. Hintz</td>
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<tr>
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Abstract

Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed range theorem; spectral theory of self-adjoint operators in Hilbert spaces.

Objective

Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature

Recommended references include the following:


Prerequisites / notice

Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and L^p spaces).
### Algebraic Topology I

**W** 8 credits  4G  S. Kalisnik Hintz

**Abstract**

This is an introductory course in algebraic topology, which is the study of algebraic invariants of topological spaces. Topics covered include:

- singular homology, cell complexes and cellular homology, the Eilenberg-Steenrod axioms.

**Literature**


Book can be downloaded for free at: http://www.math.cornell.edu/~hatcher/AT/ATpage.html

See also: http://www.math.cornell.edu/~hatcher/#anchor1772800

3) E. Spanier, *Algebraic topology*, Springer-Verlag

**Prerequisites / notice**

You should know the basics of point-set topology.

Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course "topology").

Some knowledge of differential geometry and differential topology is useful but not strictly necessary.

Some (elementary) group theory and algebra will also be needed.

### Commutative Algebra

**W** 10 credits  4V+1U  to be announced

**Abstract**

This course provides an introduction to commutative algebra. It serves in particular as a foundation for modern algebraic geometry.

**Objective**

The topics presented in the course will include:

- Basics facts about rings, ideals and modules
- Constructions of rings: quotients, polynomial rings, localization
- Noetherian rings and modules
- The tensor product of modules over commutative rings and its applications
- Krull dimension
- Integral extensions and the Cohen-Seidenberg theorems
- Finitely generated algebras over fields, including the Noether Normalization Theorem and the Nullstellensatz
- Primary decomposition
- Discrete valuation rings and some applications

**Literature**

Primary Reference:


Secondary References:

4. "Commutative Algebra" by N. Bourbaki

**Prerequisites / notice**

Prerequisites: Algebra I/II (or a similar introduction to the basic concepts of ring theory, including field theory).

### Number Theory I

**W** 8 credits  4G  S. Zerbes

**Abstract**

This course will give an introduction to the theory of number fields, which are fundamental objects in algebraic number theory.

In this course, we will cover the following topics:

- review of field extensions, algebraic numbers
- rings of integers, discriminants, integral bases
- examples: cyclotomic fields
- non-unique factorisation of algebraic integers, unique factorisation into prime ideals
- fractional ideals, class groups
- lattices and Minkowski's lemma, finiteness of the class group
- computations of the class number
- group of units of a number field
- Dedekind zeta functions, class number formula

**Literature**


Neukirch, *Algebraic Number Theory*, Springer

Galois theory

**Prerequisites / notice**

Galois theory

### Algebraic Geometry (University of Zurich)

**W** 9 credits  3V+2U  University lecturers

**Abstract**

Projective varieties, projective geometry, schemes.
Objective

To acquire familiarity with basic properties of projective varieties; some scheme theory.

Core Courses: Applied Mathematics and Further Appl.-Oriented Fields

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<tr>
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<tbody>
<tr>
<td>401-3651-00L</td>
<td>Numerical Analysis for Elliptic and Parabolic Partial Differential Equations</td>
<td>W</td>
<td>9</td>
<td>4V+1U</td>
<td>H. Ammari</td>
</tr>
</tbody>
</table>

3rd year ETH BSc Mathematics and MSc Mathematics and MSc Applied Mathematics students. Other ETH-students are advised to attend the course "Numerical Methods for Partial Differential Equations" (401-0674-00L) in the CSE curriculum during the spring semester.

Abstract

This course gives a comprehensive introduction into the numerical treatment of linear and nonlinear elliptic boundary value problems, related eigenvalue problems and linear, parabolic evolution problems. Emphasis is on theory and the foundations of numerical methods. Practical exercises include MATLAB implementations of finite element methods.

Objective

Participants of the course should become familiar with
* concepts underlying the discretization of elliptic and parabolic boundary value problems
* analytical techniques for investigating the convergence of numerical methods for the approximate solution of boundary value problems
* methods for the efficient solution of discrete boundary value problems
* implementational aspects of the finite element method

Content

The course will address the mathematical analysis of numerical solution methods for linear and nonlinear elliptic and parabolic partial differential equations. Functional analytic and algebraic (De Rham complex) tools will be provided. Primal, mixed and nonstandard (discontinuous Galerkin, Virtual, Trefftz) discretizations will be analyzed. Particular attention will be placed on developing mathematical foundations (Regularity, Approximation theory) for a-priori convergence rate analysis. A-posteriori error analysis and mathematical proofs of adaptivity and optimality will be covered. Implementations for model problems in MATLAB and python will illustrate the theory.

A selection of the following topics will be covered:
* Elliptic boundary value problems
* Galerkin discretization of linear variational problems
* The primal finite element method
* Mixed finite element methods
* Discontinuous Galerkin Methods
* Boundary element methods
* Spectral methods
* Adaptive finite element schemes
* Singularly perturbed problems
* Sparse grids
* Galerkin discretization of elliptic eigenproblems
* Non-linear elliptic boundary value problems
* Discretization of parabolic initial boundary value problems

Literature


Additional Literature:
D. Braess: Finite Elements, THIRD Ed., Cambridge Univ. Press, (2007). (Also available in German.)


Prerequisites /

Practical exercises based on MATLAB

Former title of the course unit: Numerical Methods for Elliptic and Parabolic Partial Differential Equations

401-3601-00L Probability Theory

At most one of the three course units (Bachelor Core Courses)
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are assessed.

Key topics include:

- Basics of probability theory and stochastic processes
- Random variables, probability distributions, and expectation
- Conditional probability and expectation
- Laws of large numbers and central limit theorem
- Martingales and convergence
- Markov chains and processes
- Stochastic processes in discrete time
- Stationary processes

Literature

- D. Williams, Probability with martingales, Cambridge University Press 1991
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- H. Bauer, Probability Theory, de Gruyter 1996
- W. Härdle, Linear & Nonparametric Regression. Springer 2003
- E. W. Freiberg, Linear statistical models. An introduction to regression analysis, WH. Freeman 1986
- P. L. Bühlmann, Algorithmics and Optimization. Springer 2018
- D. Williams, Probability with martingales, Cambridge University Press 1991
- H. Bauer, Probability Theory, de Gruyter 1996
- D. Williams, Probability with martingales, Cambridge University Press 1991

Prerequisites / notice

This course is a prerequisite for the following courses:

- 401-3602-00L Applied Stochastic Processes
- 401-3642-00L Brownian Motion and Stochastic Calculus

Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

Lecture notes will be available in electronic form.

This course is not assessed.

Abstract

Basics of probability theory and the theory of stochastic processes in discrete time.

Objective

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

- Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes

will be available in electronic form.

This course is not assessed.

Abstract

The course covers the basics of inferential statistics.

Objective

This course covers the basics of inferential statistics.

Content

Key topics include:

- Statistical inference
- Hypothesis testing
- Confidence intervals
- Regression analysis
- Analysis of variance
- Nonparametric methods

Lecture notes

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- Statistical inference
- Hypothesis testing
- Confidence intervals
- Regression analysis
- Analysis of variance
- Nonparametric methods

Lecture notes

will be available in electronic form.

This course is not assessed.

Abstract

The course covers the basics of inferential statistics.

Objective

This course covers the basics of inferential statistics.

Content

Key topics include:

- Statistical inference
- Hypothesis testing
- Confidence intervals
- Regression analysis
- Analysis of variance
- Nonparametric methods

Lecture notes

will be available in electronic form.

This course is not assessed.
Advanced design and analysis methods for algorithms and data structures: Random(ized) Search Trees, Point Location, Minimum Cut, Linear Programming, Randomized Algebraic Algorithms (matchings), Probabilistically Checkable Proofs (introduction).

Studying and understanding of fundamental concepts in algorithms, data structures and complexity theory.


### Core Courses: Further Application-Oriented Fields

For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>C. Anastasiou</td>
</tr>
</tbody>
</table>
| Objective       | Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.
| Content         | The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.
| Lecture notes   | Auf Moodle |
| Literature      | G. Baym, Lectures on Quantum Mechanics
|                | E. Merzbacher, Quantum Mechanics
|                | L.I. Schiff, Quantum Mechanics
|                | R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
|                | J.J. Sakurai: Modern Quantum Mechanics
|                | A. Messiah: Quantum Mechanics I
|                | S. Weinberg: Lectures on Quantum Mechanics

### Fostered competencies

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

### Social Competencies

- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

### Personal Competencies

- Adaptable and Flexible: not assessed
- Negotiation: not assessed

### Electives

#### Selection: Algebra, Number Thy, Topology, Discrete Mathematics, Logic

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Does not take place this semester.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.</td>
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<tr>
<td>Content</td>
<td>Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.</td>
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</tbody>
</table>

401-3034-00L  | Axiomatic Set Theory   | W    | 8 credits | 3V+1U | L. Halbeisen |
| Lecture notes  | Ich werde mich weitgehend an mein Buch "Combinatorial Set Theory" (2nd ed., 2017) halten. |
| Literature     | "Combinatorial Set Theory: with a gentle introduction to forcing" (Springer-Verlag 2017) |

https://link.springer.com/book/10.1007/978-3-319-60231-8

#### Selection: Geometry
At the end of the course students will be able to differentiate between three types of manifolds, give examples showing various phenomena, and prove some fundamental results about them (like the Schoenflies theorem, the generalised Poincaré conjecture, the existence of exotic smooth structures), several of which have been awarded with Fields medals.

Objective

At the end of the course students will be able to construct and analyse models of finite manifolds. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

Content

Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Möbius planes, error correcting codes, block design.

Literature

- Max Jeger, Endliche Geometrien, ETH Skript 1988
- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983
- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press
- Dembowski: Finite Geometries.
Applied Analysis of Variance and Experimental Design

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Applied Statistical Regression

Abstract
This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

Objective
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

Content
The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes
A script will be available.

Literature
Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

Bayesian Statistics

Abstract
Introduction to the Bayesian approach to statistics: decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.

Objective
Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.

Content
Topics that we will discuss are:

- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods)

Lecture notes
A script will be available in English.

Literature

Prerequisites / notice
Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.
In the Bachelor’s programme in Mathematics 401-3913-00L Mathematical Foundations for Finance is eligible as an elective course, but only if 401-3889-00L Introduction to Mathematical Finance isn’t recognised for credits (neither in the Bachelor’s nor in the Master’s programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

<table>
<thead>
<tr>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3922-00L</td>
<td>Life Insurance Mathematics</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>M. Koller</td>
</tr>
<tr>
<td>Abstract</td>
<td>The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.</td>
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<tr>
<td>401-3925-00L</td>
<td>Non-Life Insurance: Mathematics and Statistics</td>
<td>W</td>
<td>8</td>
<td>4V+1U</td>
<td>M. V. Wüthrich</td>
</tr>
<tr>
<td>Abstract</td>
<td>The lecture aims at providing a basis in non-life insurance mathematics which forms a core subject of actuarial science. It discusses collective risk modeling, individual claim size modeling, approximations for compound distributions, ruin theory, premium calculation principles, tariffification with generalized linear models and neural networks, credibility theory, claims reserving and solvency.</td>
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<tr>
<td>Objective</td>
<td>The student is familiar with the basics in non-life insurance mathematics and statistics. This includes the basic mathematical models for insurance liability modeling, pricing concepts, stochastic claims reserving models and ruin and solvency considerations.</td>
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<tr>
<td>Content</td>
<td>The following topics are treated: Collective Risk Modeling, Individual Claim Size Modeling, Approximations for Compound Distributions, Ruin Theory in Discrete Time, Premium Calculation Principles, Tariffification, Generalized Linear Models and Neural Networks, Bayesian Models and Credibility Theory, Claims Reserving, Solvency Considerations.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>The exams ONLY take place during the official ETH examination period (no semester end exams), and only in person exams (i.e. no remote exams).</td>
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<tr>
<td>Prerequisites / notice</td>
<td>This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under <a href="http://www.actuaries.ch">www.actuaries.ch</a>.</td>
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</table>

Fostered competencies
- Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management.
- Method-specific Competencies: assessed, assessed, assessed, assessed, not assessed, assessed, not assessed.

401-3927-00L Mathematical Modelling in Life Insurance

Does not take place this semester.

Abstract
In life insurance, it is essential to have adequate mortality tables, be it for reserving or pricing purposes. The course provides the tools necessary to create mortality tables from scratch. Additionally, we study various guarantees embedded in life insurance products and learn to price them with the help of stochastic models.

Objective
The course’s objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn to price embedded options in life insurance. Aside of the mere application of specific models, they should develop an intuition for the various drivers of the value of these options.

Content
Following main topics are covered:
1. Guarantees and options embedded in life insurance products.
   - Stochastic valuation of participating contracts
   - Stochastic valuation of Unit Linked contracts
2. Mortality Tables:
   - Determining raw mortality rates
   - Smoothing techniques: Whittaker-Henderson, smoothing splines, ...
   - Trends in mortality rates
   - Stochastic mortality model due to Lee and Carter
   - Neural Network extension of the Lee-Carter model
   - Integration of safety margins

Lecture notes
Lectures notes and slides will be provided.

Prerequisites / notice
The exams ONLY take place during the official ETH examination period.

Good knowledge in probability theory and stochastic processes is assumed. Some knowledge in financial mathematics is useful.

401-3928-00L Reinsurance Analytics

Does not take place this semester.

Abstract
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, experience and exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

Lecture notes
Slides and lecture notes will be made available.

Prerequisites / notice
Basic knowledge in statistics, probability theory, and actuarial techniques.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

401-3931-00L Responsible Machine Learning with Insurance Applications

Abstract
This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

Objective
The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

Content
- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

Prerequisites / notice
This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Selection: Mathematical Physics, Theoretical Physics

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1725 of 2416
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

### Literature

Suggested textbooks:

- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

<table>
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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
<td>A. Steger</td>
</tr>
<tr>
<td>252-1425-00L</td>
<td>Geometry: Combinatorics and Algorithms</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>B. Gärtner, E. Welzl, M. Hoffmann</td>
</tr>
</tbody>
</table>

### Objective

Students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content

Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments. Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at [https://moodle-app2.let.ethz.ch/course/view.php?id=15757](https://moodle-app2.let.ethz.ch/course/view.php?id=15757)

Lecture notes

Lectures will be on the blackboard only, but there will be a set of typset lecture notes which follow the class closely.

Prerequisites / notice

Students are expected to have a mathematical background and should be able to write rigorous proofs.

### Auswahl: Theoretical Computer Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Lecturers</th>
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<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
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<tr>
<td>252-1425-00L</td>
<td>Geometry: Combinatorics and Algorithms</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>B. Gärtner, E. Welzl, M. Hoffmann</td>
</tr>
</tbody>
</table>

### Abstract

This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content

The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

Literature

- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

Lecture notes

Yes.

Literature

Lecture notes

yes

Literature


Prerequisites / notice

Prerequisites: The course assumes basic knowledge of discrete mathematics and algorithms, as supplied in the first semesters of Bachelor Studies at ETH.

Outlook: In the following spring semester there is a seminar "Geometry: Combinatorics and Algorithms" that builds on this course. There are ample possibilities for Semester-, Bachelor- and Master Thesis projects in the area.

Selection: Further Realms and Some UZH Courses

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0000-00L</td>
<td>Communication in Mathematics</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>not available</td>
</tr>
</tbody>
</table>

**Abstract**

This course teaches fundamental communication skills in mathematics: how to write clearly and how to structure mathematical content for different audiences, from theses, to preprints, to personal statements in applications. In addition, the course will help you establish a working knowledge of LaTeX.

**Objective**

Knowing how to present written mathematics in a structured and clear manner.

**Content**

Topics covered include:

- Language conventions and common errors.
- How to write a thesis (more generally, a mathematics paper).
- How to use LaTeX.
- How to write a personal statement for Masters and PhD applications.

**Prerequisites / notice**

There are no formal mathematical prerequisites.

<table>
<thead>
<tr>
<th>Number</th>
<th>Reading Course #</th>
<th>W</th>
<th>2</th>
<th>4A</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3502-72L</td>
<td>To start an individual reading course, contact an authorised supervisor</td>
<td></td>
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</tbody>
</table>

**Abstract**

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

<table>
<thead>
<tr>
<th>Number</th>
<th>Reading Course #</th>
<th>W</th>
<th>3</th>
<th>6A</th>
<th>Supervisors</th>
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<tr>
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<td>To start an individual reading course, contact an authorised supervisor</td>
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</table>

**Abstract**

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

<table>
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<tr>
<th>Number</th>
<th>Reading Course #</th>
<th>W</th>
<th>4</th>
<th>9A</th>
<th>Supervisors</th>
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<tbody>
<tr>
<td>401-3504-72L</td>
<td>To start an individual reading course, contact an authorised supervisor</td>
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</table>

**Abstract**

For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

<table>
<thead>
<tr>
<th>Number</th>
<th>Guarantees for Machine Learning</th>
<th>W</th>
<th>7</th>
<th>3V+1U+2A</th>
<th>F. Yang, A. Sanyal</th>
</tr>
</thead>
</table>

**Abstract**

This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

**Objective**

By the end of the semester students should be able to

- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work

- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions

- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project

- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics:

- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g., in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:

- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

Prerequisites

Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as “Introduction to Machine Learning”, “Regression”, “Statistical Modelling”. In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH).

Literature

- Teta - A Mathematical Primer on Quantum Mechanics
- Schmüdgen – Unbounded Self-adjoint Operators on Hilbert Space

401-8815-72L Mathematical Aspects of Quantum Mechanics (University of Zurich)  
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.  
UZH Module Code: MAT631  
Mind the enrolment deadlines at UZH:  
https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Abstract

The course aims at presenting the basic theory of Quantum Mechanics from the mathematical point of view. No prior knowledge of Quantum Mechanics is required, and the language and tools necessary to develop the theory will be explicitly introduced.

Objective

After the course students should have learned topics of spectral theory for unbounded operators and the description of simple models of one-particle quantum systems.

Content

We will start with the main mathematical tools of QM: the theory of Hilbert spaces and unbounded operators, self-adjoint and unitary operators, and the spectral theorem. The standard axiomatic description of Quantum Mechanics, main motivation behind the above topics, will also be presented and discussed. This will be followed by the analysis of simple models of one-particle systems such as the free particle, the harmonic oscillator, and the hydrogen atom. Further topics as conservation laws and the angular momentum operators will also be discussed. If time permits, we will also touch more advanced topics, as for example the theory of general Schrödinger operators and the semiclassical approximation.

Literature

- Lecture note written by Benjamin Schlein for the course MAT631 Mathematical Aspects of Quantum Mechanics for the Spring Semester 2018
- Schmüdgen – Unbounded Self-adjoint Operators on Hilbert Space

401-8571-72L Differential Forms in Algebraic Topology (University of Zurich)  
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.  
UZH Module Code: MAT736  
Mind the enrolment deadlines at UZH:  
https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Abstract

This class will focus on those spaces that have a structure of differentiable manifolds and will use, as primary tools, differential forms on them. As a first example of invariants we will consider the de Rham cohomology, namely, spaces of closed forms modulo exact forms.

Objective

Understanding the basic concepts and applying them to a variety of situations.

Content

This class will focus on those spaces that have a structure of differentiable manifolds and will use, as primary tools, differential forms on them. As a first example of invariants we will consider the de Rham cohomology, namely, spaces of closed forms modulo exact forms. This approach is “less elementary” than others, as it requires the notions of differentiable manifold and of differential form and as it uses integration as an essential tool. On the other hand, for those that are already familiar with these concepts, it provides a more intuitive approach. Moreover, several results are of direct importance to applications, e.g., in physics.

Literature


Core Courses (Mathematics Master)

Electives (Mathematics Master)
ELECTIVES (ONLY CONDITIONALLY RECOGNISED)

In the Bachelor's programme in Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course, but only if 401-3889-00L Introduction to Mathematical Finance isn't recognised for credits (neither in the Bachelor nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4 credits</td>
<td>3V+2U</td>
<td>M. Schweizer</td>
</tr>
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</table>

Abstract
First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective
This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Content
Topics to be covered include
- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Lecture notes
See information on course homepage

Prerequisites / notice
Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitslehre").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

FOSTERED COMPETENCIES

- Concepts and Theories
- Techniques and Technologies

METHOD-SPECIFIC COMPETENCIES

- Analytical Competences
- Decision-making

PERSONAL COMPETENCIES

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

SEMINARS

NOTICE: The number of seminar places is limited, and the special selection procedure should help to allocate the places not primarily according to the registration time. Everybody is waitlisted first when he/she tries to register for a seminar in myStudies. Moreover: Only one mathematics seminar can be chosen per semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3550-72L</td>
<td>Topology and Combinatorics of Zero Sets of Polynomials in the Plane</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>P. Feller</td>
</tr>
</tbody>
</table>

Abstract
The seminar consists of student presentations on topics from "A Singular Mathematical Promenade" written by Étienne Ghys.

Objective
Understanding different aspects of the combinatorics of zero sets of polynomials as presented in "A Singular Mathematical Promenade" written by Étienne Ghys.

Content
See https://metaphor.ethz.ch/x/2022/ha/401-3550-72L/

"A singular mathematical promenade" by Étienne Ghys.

Requirements (beyond first year Bachelor courses):
- One semester introduction to complex analysis (as provided by D-Math's "Funktionentheorie")
- One semester introduction to topology (as provided by D-Math's "Topologie")

Number of participants limited to 24.

401-3680-72L Persistent Homology

Does not take place this semester.

401-3350-72L Elliptic Partial Differential Equations

Number of participants limited to 12.

401-4350-72L Introduction to Partial Differential Equations

Number of participants limited to 24.

401-3760-72L Topics in Fluid Dynamics

Number of participants limited to 12.

401-3940-72L Student Seminar in Mathematics and Data: Differential Privacy

Number of participants limited to 12.

401-3620-20L Student Seminar in Statistics: Inference in Some Non-Standard Regression Problems

Number of participants limited to 24.

Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics.

Also offered in the Master Programmes Statistics resp. Data Science.

Abstract
Review of some non-standard regression models and the statistical properties of estimation methods in such models.
The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).

Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, linearity might be too simplistic to capture the actual relationship between some response and given covariates. Also, there are many real data problems where linearity is plausible but the actual pairing between the observed covariates and responses is completely lost or at partially. In this seminar, we review some of the non-classical regression models and the statistical properties of the estimation methods considered by well-known statisticians and machine learners. This will encompass:

1. Monotone regression
2. Single index model
3. Unlinked regression

In the following is the tentative material that will be read and studied by each pair of students (all the items listed below are available through the ETH electronic library or arXiv). Some of the items might change.

8. "Linear regression with shuffled data: statistical and computation limits of permutation recovery" by A. Pananjady, M. Wainwright and T. A. Courtade , 2018, IEEE transactions in Information Theory, Volume 64, 3286-3300
9. "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS
11. "Uncoupled isotonic regression via minimum Wasserstein deconvolution" by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27

The seminar covers theory and algorithms for rational interpolation based on classical and modern literature. The various topics have to be presented by groups of students.

The simplest and most widely used function system for approximation in computational mathematics are polynomials. They are ideally suited for smooth (analytic) functions. However, in many applications we encounter functions with kinks and other kinds of singularities. In this case approximation by rational functions, that is, quotients of polynomials, may be vastly superior. This is why rational approximation and interpolation is receiving increased attention for the construction of surrogate models in model order reduction.

This seminar will study a number of research papers dealing with both theoretical and algorithmic aspects of rational approximation and interpolation.

Will be announced in due course

Preparatory meeting: Mon, Sep 19, 2022, 18:00 on ZOOM, Meeting ID: 698 4220 0325, Password: RAP HS22

Every presentation has to be done jointly by a group of 2-3 students with presenters selected at random. Every participant will have to present on 2-3 occasions.

Scientific Works in Mathematics
Target audience:
Third year Bachelor students;
Master students who cannot document to have received an adequate training in working scientifically.

Abstract
Introduction to scientific writing for students with focus on publication standards and ethical issues, especially in the case of citations (references to works of others.)

Prerequisites / notice

Lunch Sessions – Thesis Basics for Mathematics
Students Details and registration for the optional MathBib training course: https://www.math.ethz.ch/mathbib-schulungen

Bachelor's Thesis
Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics is required. For more information, see www.math.ethz.ch/intranet/students/study-administration/theses.html

The purpose of the BSc thesis is to deepen knowledge in a certain subject chosen by the student. In their BSc thesis, students should demonstrate their ability to carry out independent work in mathematics and to organize results in a written report.

Science in Perspective

Language Courses

Additional Courses

### Mathematics Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<th>Description</th>
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<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<td>Suitable for doctorate</td>
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### Key for Hours

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<td>V</td>
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<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS  European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Mathematics TC

Detailed information on the programme at: www.ethz.ch/didaktische-ausbildung

Educational Science

General course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0228-00L</td>
<td>Formation of Knowledge in STEM Fields in Primary and Secondary School</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>U. Markwalder</td>
</tr>
</tbody>
</table>

Abstract

The event includes a block seminar as well as an assignment period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

Objective

Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

Subject Didactics and Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Enrolment in either Mathematics Didactics I or Mathematics Didactics II (spring semester) is compulsory.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3971-11L</td>
<td>Mathematics Didactics I</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>A. Barth</td>
</tr>
</tbody>
</table>

Abstract

On the basis of their understanding of mathematics, of the knowledge acquired from research into teaching/learning and subject teaching, and also of best practice, students who have completed this course will be in a position to draft motivating learning arrangements, with contribution appeal, which trigger and maintain learning processes. The aim here is to implement a corresponding teaching plan, so that the mathematics tuition that is given has a general-education value, on the one hand, and ensures that pupils acquire the fundamental knowledge necessary for studying at university, on the other hand.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-9987-00L</td>
<td>Teaching Internship Including Examination Lessons Mathematics</td>
<td>O</td>
<td>4 credits</td>
<td>9P</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

Abstract

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons. They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils. They learn the skills of the teaching trade. They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution. Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content


Lecture notes

Dokument: schriftliche Vorbereitung für Prüfungsseminare.

Literature

Wird von der Praktikumsemblehrperson bestimmt.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-9983-00L</td>
<td>Mentored Work Subject Didactics Mathematics A</td>
<td>O</td>
<td>2 credits</td>
<td>4A</td>
<td>M. Akveld, A. Barth, L. Halbeisen, N. Hungerbühler, C. Rüede</td>
</tr>
</tbody>
</table>

Abstract

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.
Objective

The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Themenatische Schwerpunkte

Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.

Lernformen


Literatur

Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

► Specialized Courses in Respective Subject with Educational Focus

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3057-00L</td>
<td>Finite Geometries II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
</tbody>
</table>

Abstract

Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

Objective

Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

Content

Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design.

Literature

- Max Jeger, Endliche Geometrien, ETH Skript 1988
- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983
- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press
- Dembowski: Finite Geometries.

401-3059-00L | Combinatorics II | W    | 4    | 2G    | N. Hungerbühler |

Abstract

The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.

Objective

Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content

Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdie's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

401-0293-00L | Mathematics III | W    | 5    | 3V+2U | A. Caspar, N. Hungerbühler |

Abstract

Vertiefung der mehrdimensionalen Analysis mit Schwerpunkt in der Anwendung der partiellen Differentialgleichungen, Vertiefung der Linearen Algebra und Einführung in die Systemanalyse und Modellbildung.

Objective

Die Studierenden
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenfalls explizit berechnen: diskret/kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten.
Einführung Modellbildung

- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Lineare Modelle

- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen

- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle

- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen: Vorgänge, die von Raum und Zeit anhängen

- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Lecture notes

Lecture notes

Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Literature

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Prerequisites / notice

Vorlesungen Mathematik I/II

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Cooperation and Teamwork

Personal Competencies
- Creative Thinking
- Critical Thinking

401-9985-00L Mentored Work Specialised Courses in the Respective O
Subject with an Educational Focus Mathematics A
Subject with an Educational Focus in Mathematics for TC and Teaching Diploma.

Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective

The aim is for the students
- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content

Thematische Schwerpunkte:

Lernformen:

Lecture notes

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

Colloquia

Number Title Type ECTS Hours Lecturers
401-5960-00L Colloquium on Mathematics, Computer Science, and Education E- 0 credits N. Hungerbühler, M. Akveld, D. Grawehr Morath, J. Hromkovic, P. Spindler

Abstract

Didactics colloquium
<table>
<thead>
<tr>
<th>Key for Type</th>
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<tr>
<td>O</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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<tr>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Mathematics Teaching Diploma

Detailed information on the programme at: www.ethz.ch/didaktische-ausbildung

Educational Science

Course offerings in the category Educational Science are listed under “Programme: Educational Science for Teaching Diploma and TC”.

see Educational Science Teaching Diploma

Subject Didactics in Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-3971-11L</td>
<td>Mathematics Didactics I</td>
<td>O</td>
<td>4</td>
<td>2G</td>
<td>A. Barth</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Mathematics Teaching Diploma or Mathematics TC at ETH or in Mathematics Teaching Diploma at UZH.</td>
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<tr>
<td></td>
<td>Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching various topics in mathematics. Methodological suggestions are compared and draft tuition concepts discussed.</td>
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<td></td>
<td>Objective</td>
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<td></td>
<td>On the basis of their understanding of mathematics, of the knowledge acquired from research into teaching/learning and subject teaching, and also of best practice, students who have completed this course will be in a position to draft motivating learning arrangements, with cognitive appeal, which trigger and maintain learning processes. The aim here is to implement a corresponding teaching plan, so that the mathematics tuition that is given has a general-education value, on the one hand, and ensures that pupils acquire the fundamental knowledge necessary for studying at university, on the other hand.</td>
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<tr>
<td>401-9983-00L</td>
<td>Mentored Work Subject Didactics Mathematics A n</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>M. Akveld, A. Barth, C. Rüede</td>
</tr>
<tr>
<td></td>
<td>Mentored Work Subject Didactics Mathematics for TC and Teaching Diploma.</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.</td>
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<td>The objective is for the students:</td>
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<td></td>
<td>- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.</td>
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<td></td>
<td>Thematische Schwerpunkte</td>
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<tr>
<td></td>
<td>Die Gegenstände der mentorierten Arbeit in Fachdidaktik stammen in der Regel aus dem gymnasialen Unterricht.</td>
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<td>Lernformen</td>
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<td>Lecture notes</td>
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<td></td>
<td>Eine kurze Anleitung zur mentorierten Arbeit in Fachdidaktik wird zur Verfügung gestellt.</td>
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<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>Die Literatur ist themenspezifisch. Die Studierenden beschaffen sie sich in der Regel selber (siehe Lernziele). In besonderen Fällen wird sie vom Betreuer zur Verfügung gestellt.</td>
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<td>401-9984-00L</td>
<td>Mentored Work Subject Didactics Mathematics B n</td>
<td>O</td>
<td>2</td>
<td>4A</td>
<td>M. Akveld, A. Barth, C. Rüede</td>
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<td>Mentored Work Subject Didactics Mathematics for Teaching Diploma and for students upgrading TC to Teaching Diploma.</td>
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Professional Training in Mathematics

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<tr>
<td>401-9970-00L</td>
<td>Introductory Internship Mathematics</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>N. Hungerbühler</td>
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<tr>
<td></td>
<td>Enrolment only possible with matriculation in Mathematics Teaching Diploma or Mathematics TC at ETH. It is advisable to enrol in this course not prior to the first Mathematics Didactics course and not after the second Mathematics Didactics course.</td>
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Data: 01.11.2022 12:41
Autumn Semester 2022
Page 1737 of 2416
Die Studierenden sammeln Erfahrungen in der Unterrichtsführung, der Auseinandersetzung mit Lernenden, der Klassenbetreuung und der

Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.

Professional Exercises I

Students learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics. Methodological suggestions are compared and draft tuition concepts discussed.

1G

N. Hungerbühler

Wird von der Praktikumslehrperson bestimmt.

Professional Exercises I

Teaching Internship Mathematics

On the basis of their understanding of mathematics, of the knowledge acquired from research into teaching/learning and subject teaching, and also of best practice, students who have completed this course will be in a position to draft motivating learning arrangements, with cognitive appeal, which trigger and maintain learning processes. The aim here is to implement a corresponding teaching plan, so that the mathematics tuition that is given has a general-education value, on the one hand, and ensures that pupils acquire the fundamental knowledge necessary for studying at university, on the other hand.

Prerequisites / notice

This course is to be chosen jointly with 401-3972-00L.

Teaching Internship Mathematics II

- Students should learn about and learn to use findings from empirical research into mathematical didactics and best practice, as well as theoretical approaches to teaching mathematics.
- Methodological suggestions are compared and draft tuition concepts discussed.

Teaching Internship for students upgrading TC to Teaching Diploma

This is a supplement to the Teaching Internship required to obtain a Master of Advanced Studies in Secondary and Higher Education in the corresponding subject. It is aimed at enlarging the already acquired teaching experience. Students observe 10 lessons and teach 15 lessons independently.

Teaching Diploma or Mathematics TC at ETH.

Enrolment only possible with matriculation in Mathematics

Simultaneous enrollment in Mathematics Didactics - course unit 401-3971-11L - is compulsory.

Teaching Diploma

This course is to be chosen jointly with 401-3971-11L.

Enrolment only possible with matriculation in Mathematics

Simultaneous enrollment in Mathematics Didactics - course unit 401-3971-11L - is compulsory.

Teaching Diploma or Mathematics TC at ETH.

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Teaching Diploma or Mathematics TC at ETH.

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Teaching Diploma or Mathematics TC at ETH.

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Die gehaltene Lektion wird kriteriernbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltene Lektion im Rahmen eines kurzen Kolloquiums.

Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

Nach Abschluss der übrigen Ausbildung.

401-9991-02L Examination Lesson II Mathematics
Simultaneous enrolment in "Examination Lesson I Mathematics" (401-9991-01L) is compulsory.

Abstract
In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.

Objective
On the basis of a specified topic, the candidate shows that they are in a position
- to develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- to analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

Content

Die gehaltene Lektion wird kriteriernbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltene Lektion im Rahmen eines kurzen Kolloquiums.

Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

Nach Abschluss der übrigen Ausbildung.


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<td>401-3059-00L</td>
<td>Combinatorics II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
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<tr>
<td></td>
<td><em>Does not take place this semester.</em></td>
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<tr>
<td>Abstract</td>
<td>The course Combinatorics I and II is an introduction into the field of enumerative combinatorics.</td>
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<tr>
<td>Objective</td>
<td>Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.</td>
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<td>Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsides's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.</td>
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<td></td>
<td>- Albrecht Beutelspacher: <em>Einführung in die endliche Geometrie I.II. Bibliographisches Institut 1983</em></td>
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<td>Finite Geometries II</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Hungerbühler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.</td>
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<td>Objective</td>
<td>Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.</td>
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<tr>
<td>Content</td>
<td>Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Möbius planes, error correcting codes, block design</td>
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<tr>
<td>401-0293-00L</td>
<td>Mathematics III</td>
<td>W</td>
<td>5</td>
<td>3V+2U</td>
<td>A. Caspar, N. Hungerbühler</td>
</tr>
</tbody>
</table>
| Objective    | Die Studierenden
- verstehen Mathematik als Sprache zur Modellbildung und als Werkzeug zur Lösung angewandter Probleme in den Naturwissenschaften.
- können anspruchsvolle Modelle analysieren, Lösungen qualitativ beschreiben oder allenfalls explizit berechnen: diskret/ kontinuierlich in Zeit, Ebene und Raum.
- können Beispiele und konkrete arithmetische und geometrische Situationen aus Anwendungen mit Methoden der höheren Mathematik interpretieren und bearbeiten. |
Content

Einführung Modellbildung

- SIR-Modelle: Ausbreitung von Krankheiten bei Epidemien
- Pocken-Modell: Was ist der Effekt von Impfungen?

Lineare Modelle

- Vektorräume
- Lösungsraum eines Linearen DGL-Systems
- Diagonalisierbarkeit und Normalformen
- Exponential einer Matrix

Fourier-Reihen

- Euklidische Vektorräume
- Orthogonale Projektion
- Anwendungen

Nichtlineare Modelle

- Stationäre Lösungen, Qualitative Aussagen
- Mehrdimensionale Modelle: Räuber-Beute, Lotka-Volterra

Partielle Differentialgleichungen: Vorgänge, die von Raum und Zeit anhängen

- Einführung, Repetition, Beispiele
- Fourier-Methoden: Wärmeleitung, Laplace, Wellengleichung, Filter, Computertomographie

Laplace-Transformation

- Definition und Notation
- Rechenregeln
- Anwendungsbeispiele

Lecture notes

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler
- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Literature

- Buch: "Mathematische Modellbildung in den Life Sciences", A. Caspar und N. Hungerbühler

Prerequisites / notice

Vorlesungen Mathematik I/II

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies

- Cooperation and Teamwork

Personal Competencies

- Creative Thinking
- Critical Thinking

Subject with an Educational Focus in Mathematics for Teaching Diploma

401-9985-00L

Mentored Work Specialised Courses in the Respective O

Subject with an Educational Focus Mathematics A

Objectives:

- to familiarise themselves with a new topic by obtaining material and studying the sources, so that they can selectively extend their specialist competence in this way.
- to independently develop a text on the topic, with special focus on its mathematical comprehensibility in respect of the level of knowledge of the targeted readership.
- To try out different options for specialist further training in their profession.

Content:

Thematische Schwerpunkte:


Lernformen:


Abstract:

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Lecture notes

Eine Anleitung zur mentorierten Arbeit in FV wird zur Verfügung gestellt.

Literature

Die Literatur ist themenspezifisch. Sie muss je nach Situation selber beschafft werden oder wird zur Verfügung gestellt.

Prerequisites / notice

Die Arbeit sollte vor Beginn des Praktikums abgeschlossen werden.

401-9986-00L

Mentored Work Specialised Courses in the Respective O

Subject with an Educational Focus Mathematics B

Abstract:

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.
### Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

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**Objective**: Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

**Content**: Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsle's lemma, cycle index, Polya's theorems, applications to graph theory and isomers.

| 401-3057-00L | Finite Geometries II                      | W    | 4    | 2G   | N. Hungerbühler            |

**Abstract**: Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

**Objective**: Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

**Content**: Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler's thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Moebius planes, error correcting codes, block design

**Literature**
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- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press
- Dembowski: Finite Geometries.

| 252-0855-00L | Computer Science in Secondary School Mathematics | W | 4 | 3G | J. Hromkovic, G. Serafini |

**Abstract**: The unit "Computer Science in Secondary School Mathematics" addresses key contributions of computer science to general education, the tight relations between the algorithmic and the mathematical way of thinking, and the thoughtful choice of computer science topics for high school mathematics classes.

**Objective**: The general goal of the course consists in presenting ways to teach fundamentals of computer science, which are closely related to contents and methods of mathematics. After attending the course unit, a mathematics teacher is able to teach selected fundamentals of computer science in mathematics classes.

**Content**: The students understand the fundamental concepts of computer science in the context of a broad and deep knowledge. Through this understanding, they manage to prepare teaching materials for a successful knowledge transfer and to pass their passion for the subject on to their pupils.

The students student various teaching methods as well as their advantages and disadvantages. They can handle inhomogeneous prior knowledge of the learners inside a class. Besides holding classes, the students do care about the individual pupil support.

They encourage the autonomy of the learners, manage to work with diverse target groups and to establish a positive learning environment.

The students are able to express themselves using a comprehensible and refined professional language, both in a spoken and a written way, and they master the basic terminology of computer science. Besides the English terms, they are familiar with the corresponding German expressions. The students are able to produce detailed, matured, linguistically correct and design-wise appealing teaching materials.

**Literature**
- J. Hromkovic et al.: "Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen"
- Lehrwerksreihe "Einfach Informatik"

https://einfachinformatik.inf.ethz.ch/


*see Compulsory Elective Courses Teaching Diploma*
Colloquium on Mathematics, Computer Science, and Education
Subject didactics for mathematics and computer science teachers.

ECTS: 0 credits
Lecturers: N. Hungerbühler, M. Akveld, D. Grawehr Morath, J. Hromkovic, P. Spindler

Abstract: Didactics colloquium

Mathematics Teaching Diploma - Key for Type

| O   | Compulsory                  | E-  | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended | Z   | Courses outside the curriculum         |
| W   | Eligible for credits        | Dr  | Suitable for doctorate                 |

Key for Hours

| V  | lecture                     | P   | practical/laboratory course          |
| G  | lecture with exercise       | A   | independent project                  |
| U  | exercise                    | D   | diploma thesis                       |
| S  | seminar                     | R   | revision course / private study       |
| K  | colloquium                  |     |                                        |

ECTS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Mathematics Master

Core Courses

For the Master's degree in Applied Mathematics the following additional condition (not manifest in myStudies) must be obeyed: At least 15 of the required 28 credits from core courses and electives must be acquired in areas of applied mathematics and further application-oriented fields.

Core Courses: Pure Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3225-00L</td>
<td>Introduction to Lie Groups</td>
<td>W</td>
<td>8 credits</td>
<td>4G</td>
<td>M. Burger</td>
</tr>
<tr>
<td>Abstract</td>
<td>Topological groups and Haar measure. Definition of Lie groups, examples of local fields and examples of discrete subgroups; basic properties; Lie subgroups. Lie algebras and relation with Lie groups: exponential map, adjoint representation. Semisimplicity, nilpotency, solvability, compactness: Killing form, Lie's and Engel's theorems. Definition of algebraic groups and relation with Lie groups.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The goal is to have a broad though foundational knowledge of the theory of Lie groups and their associated Lie algebras with an emphasis on the algebraic and topological aspects of it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Literature | A. Knapp: "Lie groups beyond an Introduction" (Birkhäuser)  
A. Sagle & R. Walde: "Introduction to Lie groups and Lie algebras" (Academic Press, '73)  
F. Warner: "Foundations of differentiable manifolds and Lie groups" (Springer)  
H. Samelson: "Notes on Lie algebras" (Springer, '90)  
S. Helgason: "Differential geometry, Lie groups and symmetric spaces" (Academic Press, '78)  
| Prerequisites / notice | Topology and basic notions of measure theory. A basic understanding of the concepts of manifold, tangent space and vector field is useful, but could also be achieved throughout the semester. |

401-3001-61L | Algebraic Topology I | W    | 8 credits | 4G    | S. Kalisnik Hintz |
| Abstract | This is an introductory course in algebraic topology, which is the study of algebraic invariants of topological spaces. Topics covered include: singular homology, cell complexes and cellular homology, the Eilenberg-Steenrod axioms. |
See also: http://www.math.cornell.edu/~hatcher/#anchor1772800  
3) E. Spanier, "Algebraic topology", Springer-Verlag |
| Prerequisites / notice | You should know the basics of point-set topology. Useful to have (though not absolutely necessary) basic knowledge of the fundamental group and covering spaces (at the level covered in the course "topology"). Some knowledge of differential geometry and differential topology is useful but not strictly necessary. Some (elementary) group theory and algebra will also be needed. |

401-3132-00L | Commutative Algebra | W    | 10 credits | 4V+1U | to be announced |
| Abstract | This course provides an introduction to commutative algebra. It serves in particular as a foundation for modern algebraic geometry. |
| Objective | The topics presented in the course will include:  
* Basics facts about rings, ideals and modules  
* Constructions of rings: quotients, polynomial rings, localization  
* Noetherian rings and modules  
* The tensor product of modules over commutative rings and its applications  
* Krull dimension  
* Integral extensions and the Cohen-Seidenberg theorems  
* Finitely generated algebraic over fields, including the Noether Normalization Theorem and the Nullstellensatz  
* Primary decomposition  
* Discrete valuation rings and some applications |
Secondary References:  
2. "Commutative algebra, With a view towards algebraic geometry" by D. Eisenbud (GTM 150, Springer Verlag, 1995)  
4. "Commutative Algebra" by N. Bourbaki |
| Prerequisites / notice | Prerequisites: Algebra I/II (or a similar introduction to the basic concepts of ring theory, including field theory). |

401-3111-72L | Number Theory I | W    | 8 credits | 4G   | S. Zerbes |
| Abstract | This course will give an introduction to the theory of number fields, which are fundamental objects in algebraic number theory. |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1743 of 2416
Objective
In this course, we will cover the following topics:
- review of field extensions, algebraic numbers
- rings of integers, discriminants, integral bases
- examples: cyclotomic fields
- non-unique factorisation of algebraic integers, unique factorisation into prime ideals
- fractional ideals, class groups
- lattices and Minkowski's lemma, finiteness of the class group
- computations of the class number
- group of units of a number field
- Dedekind zeta functions, class number formula

Literature
Neukirch, Algebraic Number Theory, Springer

Prerequisites / notice
Galois theory

Core Courses: Applied Mathematics and Further Appl.-Oriented Fields

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3651-00L</td>
<td>Numerical Analysis for Elliptic and Parabolic Partial Differential Equations</td>
<td>W</td>
<td>9 credits</td>
<td>4V+1U</td>
<td>H. Ammari</td>
</tr>
</tbody>
</table>

Abstract
This course gives a comprehensive introduction into the numerical treatment of linear and nonlinear elliptic boundary value problems, related eigenvalue problems and linear, parabolic evolution problems. Emphasis is on theory and the foundations of numerical methods. Practical exercises include MATLAB implementations of finite element methods.

Objective
Participants of the course should become familiar with
- concepts underlying the discretization of elliptic and parabolic boundary value problems
- analytical techniques for investigating the convergence of numerical methods for the approximate solution of boundary value problems
- methods for the efficient solution of discrete boundary value problems
- implementational aspects of the finite element method

Content
The course will address the mathematical analysis of numerical solution methods for linear and nonlinear elliptic and parabolic partial differential equations. Functional analytic and algebraic (De Rham complex) tools will be provided. Primal, mixed and nonstandard (discontinuous Galerkin, Virtual, Trefftz) discretizations will be analyzed.

Particular attention will be placed on developing mathematical foundations (Regularity, Approximation theory) for a-priori convergence rate analysis. A-posteriori error analysis and mathematical proofs of adaptivity and optimality will be covered.
Implementations for model problems in MATLAB and python will illustrate the theory.

A selection of the following topics will be covered:
- Elliptic boundary value problems
- Galerkin discretization of linear variational problems
- The primal finite element method
- Mixed finite element methods
- Discontinuous Galerkin Methods
- Boundary element methods
- Spectral methods
- Adaptive finite element schemes
- Singularly perturbed problems
- Sparse grids
- Galerkin discretization of elliptic eigenproblems
- Non-linear elliptic boundary value problems
- Discretization of parabolic initial boundary value problems
In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalized linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

**Prerequisites / notice**

This is the course unit with former course title "Regression".

Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

**Literature**


**Additional Literature**

  (Also available in German.)


**Content**

This is an advanced course on mathematical finance for students with a good background in probability. The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.
**Content**

Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Solid background in linear algebra.

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**Bachelor Core Courses: Pure Mathematics**

Further restrictions apply, but in particular:
401-3531-00L Differential Geometry I can only be recognised for the Master Programme if 401-3532-00L Differential Geometry II has not been recognised for the Bachelor Programme.
Analogously for:
401-3461-00L Functional Analysis I - 401-3462-00L Functional Analysis II
401-3001-61L Algebraic Topology I - 401-3002-12L Algebraic Topology II
401-3132-00L Commutative Algebra - 401-3146-12L Algebraic Geometry
For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

**Number**  | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
401-3461-00L | Functional Analysis I | E- | 10 credits | 4V+1U | P. Hintz

**Abstract**

Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies, Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed range theorem; spectral theory of self-adjoint operators in Hilbert spaces.

**Objective**

Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

**Literature**

Recommended references include the following:

**Prerequisites / notice**

Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and L^p spaces).

401-3531-00L | Differential Geometry I | E- | 10 credits | 4V+1U | J. Serra

**Autumn Semester 2022**
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract

Objective
Introduce the classical theory of curves and surfaces (which is the precursor of modern Riemannian geometry). Invite students to use and sharpen their geometric intuition.

Introduce the language, basic tools, and some fundamental results in modern differential geometry.

Lecture notes
Partial lecture notes are available from Prof. Lang's website https://people.math.ethz.ch/~lang/

Literature
- Manfredo P. do Carmo: Differential Geometry of Curves and Surfaces
- John M. Lee: Introduction to Smooth Manifolds
- S. Montiel, A. Ros: Curves and Surfaces
- S. Kobayashi: Differential Geometry of Curves and Surfaces
- Wolfgang Kühnet: Differentialgeometrie. Kurven-Flächen-Mannigfaltigkeiten
- Dennis Barden & Charles Thomas: An Introduction to Differential Manifolds

Bachelor Core Courses: Applied Mathematics...

Further restrictions apply, but in particular:
401-3601-00L Probability Theory can only be recognised for the Master Programme if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-3601-00L | Probability Theory | E- | 10 credits | 4V+1U | W. Werner, D. Schröder

Abstract
Basics of probability theory and the theory of stochastic processes in discrete time

Objective
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:
- Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes
will be available in electronic form.

Literature
- H. Bauer, Probability Theory, de Gruyter 1996
- J. Jacod and P. Protter, Probability essentials, Springer 2004
- D. Williams, Probability with martingales, Cambridge University Press 1991

402-0205-00L Quantum Mechanics I

Abstract
General structure of quantum theory: Hilbert spaces, states and observables, equations of motion, Heisenberg uncertainty relation, symmetries, angular momentum addition, EPR paradox, Schrödinger and Heisenberg picture

Applications: simple potentials in wave mechanics, scattering and resonance, harmonic oscillator, hydrogen atom, and perturbation theory.

Objective
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

Content
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.

Lecture notes
Auf Moodle

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1747 of 2416
Evaluations

- Combinatorics II: The overall goal of this course is to provide an introduction to o-minimality and the applications of o-minimal structures.
- Finite Geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

Literature

- G. Baym, Lectures on Quantum Mechanics
- E. Merzbacher, Quantum Mechanics
- L.I. Schiff, Quantum Mechanics
- R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
- J.J. Sakurai, Modern Quantum Mechanics
- A. Messiah, Quantum Mechanics I
- S. Weinberg, Lectures on Quantum Mechanics

Fostered competencies

- Subject-specific Competencies: Concepts and Theories (assessed), Techniques and Technologies (not assessed).
- Method-specific Competencies: Analytical Competencies (assessed), Decision-making (not assessed), Media and Digital Technologies (not assessed), Problem-solving (assessed), Project Management (not assessed).
- Social Competencies: Communication (not assessed), Cooperation and Teamwork (not assessed), Customer Orientation (not assessed), Leadership and Responsibility (not assessed), Self-presentation and Social Influence (not assessed), Sensitivity to Diversity (not assessed), Negotiation (not assessed).
- Personal Competencies: Adaptability and Flexibility (not assessed), Creative Thinking (assessed), Critical Thinking (not assessed), Integrity and Work Ethics (not assessed), Self-awareness and Self-reflection (not assessed), Self-direction and Self-management (not assessed).

Evaluables: Pure Mathematics

Selection: Algebra, Number Thy, Topology, Discrete Mathematics, Logic

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-3059-00L | Combinatorics II | W | 4 credits | 2G | N. Hungerbühler

Abstract: Does not place this semester.

Objective: Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content: Contents of the lectures Combinatorics I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdie's lemmas, cycle index, Polya's theorems, applications to graph theory and isomers.


https://link.springer.com/book/10.1007/978-3-319-60231-8

401-3034-00L | Axiomatic Set Theory | W | 8 credits | 3V+1U | L. Halbeisen

Abstract: The course Axiomatic Set Theory I and II is an introduction into the field of enumerative combinatorics.

Objective: Upon completion of the course, students are able to classify combinatorial problems and to apply adequate techniques to solve them.

Content: Contents of the lectures Axiomatic Set Theory I and II: congruence transformation of the plane, symmetry groups of geometric figures, Euler's function, Cayley graphs, formal power series, permutation groups, cycles, Bunsdie's lemmas, cycle index, Polya's theorems, applications to graph theory and isomers.


https://link.springer.com/book/10.1007/978-3-319-60231-8

401-4037-72L | O-Minimality and Diophantine Applications | W | 8 credits | 4G | E. Kowalski

Abstract: O-minimal structures provide a framework for "tame topology", as envisioned for instance by Grothendieck. Although motivated by questions in model theory and real algebraic geometry, the notion the o-minimal structures was revealed by Pila, Wilkie, Zannier and others to have remarkable applications to number theory and arithmetic geometry.

Objective: The overall goal of this course is to provide an introduction to o-minimality and the applications of o-minimal structures.

Content: The first part of the course will be devoted to an introduction to model theory as a framework in which to define o-minimal structures. The main result will be the "cell decomposition theorem", which describes the shape of definable subsets of an o-minimal structure. In the second part of the course, we will discuss examples of interesting o-minimal structures, and then consider applications to number theory. These may include Pila-Wilkie counting theorem, or the Pila-Zannier strategy in the context of the Manin-Mumford conjecture.

Literature: G. Jones and A. Wilkie: O-minimality and diophantine geometry, Cambridge University Press.
L. van den Dries: Tame topology and o-minimal structures, Cambridge University Press.
A. Forey: lectures notes on o-minimality and arithmetic applications.

Prerequisites: This course is appropriate for people with basic knowledge of abstract algebra and commutative algebra. Some knowledge of differential geometry, mathematical logic or some number theory is welcome, but not required.

Selection: Geometry

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-3057-00L | Finite Geometries II | W | 4 credits | 2G | N. Hungerbühler

Abstract: Finite geometries I, II: Finite geometries combine aspects of geometry, discrete mathematics and the algebra of finite fields. In particular, we will construct models of axioms of incidence and investigate closing theorems. Applications include test design in statistics, block design, and the construction of orthogonal Latin squares.

Objective: Finite geometries I, II: Students will be able to construct and analyse models of finite geometries. They are familiar with closing theorems of the axioms of incidence and are able to design statistical tests by using the theory of finite geometries. They are able to construct orthogonal Latin squares and know the basic elements of the theory of block design.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1748 of 2416


**Content**

Finite geometries I, II: finite fields, rings of polynomials, finite affine planes, axioms of incidence, Euler’s thirty-six officers problem, design of statistical tests, orthogonal Latin squares, transformation of finite planes, closing theorems of Desargues and Pappus-Pascal, hierarchy of closing theorems, finite coordinate planes, division rings, finite projective planes, duality principle, finite Möbius planes, error correcting codes, block design.

**Literature**

- Max Jeger, Endliche Geometrien, ETH Skript 1988
- Albrecht Beutelspacher: Einführung in die endliche Geometrie I,II. Bibliographisches Institut 1983
- Margaret Lynn Batten: Combinatorics of Finite Geometries. Cambridge University Press
- Dembowskii: Finite Geometries.

<table>
<thead>
<tr>
<th>401-3533-71L</th>
<th>Generalized Nonpositive Curvature</th>
<th>W</th>
<th>6 credits</th>
<th>3V</th>
<th>U. Lang</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>CAT(0) spaces, Busemann convex spaces, metric spaces with convex geodesic bicombings, injective metric spaces and injective hulls, Gromov hyperbolicity, Helly graphs and Helly groups.</td>
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<tr>
<td>Lecture notes</td>
<td>Lecture notes will be provided.</td>
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<tr>
<td></td>
<td>- A. Papadopoulos: Metric Spaces, Convexity and Nonpositive Curvature, EMS 2005</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Basic knowledge of Riemannian geometry and functional analysis will be assumed.</td>
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</table>

<table>
<thead>
<tr>
<th>401-4571-22L</th>
<th>Topology of Manifolds</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U</th>
<th>D. Čekić</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This will be an introduction to geometric topology, a field of mathematics concerned with topological properties of manifolds. We will study both topological and smooth manifolds, and prove some fundamental results about them (like the Schoenflies theorem, the generalised Poincaré conjecture, the existence of exotic smooth structures), several of which have been awarded with Fields medals.</td>
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<tr>
<td>Objective</td>
<td>At the end of the course students will be able to differentiate between three types of manifolds, give examples showing various phenomena, and prove some classical results. They will understand what kinds of arguments are used in each of the cases, and where the difficulties arise. Moreover, they will become familiar with many open problems that are guiding current research, especially in the peculiar dimension four.</td>
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<tr>
<td>Content</td>
<td>There are several notions of a manifold -- namely, topological, piecewise-linear, and smooth -- and only in 1956 did it become clear that these objects are in fact distinct, thanks to the construction by J. Milnor of multiple smooth structures on a single topological manifold. In this course we will start with basic definitions and properties of the three types of manifolds, building our way up to cover some fundamental results.</td>
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</tr>
<tr>
<td>Literature</td>
<td>- See the lecture notes and a reference list at <a href="https://maths.dur.ac.uk/users/mark.a.powell/topological-manifolds.html">https://maths.dur.ac.uk/users/mark.a.powell/topological-manifolds.html</a></td>
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<tr>
<td>Prerequisites / notice</td>
<td>We will assume familiarity with point-set topology, the fundamental group (as covered in the course Topology), homology (as covered in Algebraic Topology I), and some basics of differential topology and vector bundles (as covered in Differential Geometry I). Some familiarity with cohomology and Poincaré duality would be useful.</td>
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</table>

### Selection: Analysis

**No offering in this semester yet**

### Selection: Further Realms and Some UZH Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0000-00L</td>
<td>Communication in Mathematics</td>
<td>W</td>
<td>2</td>
<td>1V</td>
<td>not available</td>
</tr>
<tr>
<td>Abstract</td>
<td>Don't hide your Next Great Theorem behind bad writing.</td>
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<tr>
<td>Objective</td>
<td>Knowing how to present written mathematics in a structured and clear manner. Topics covered include:</td>
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<tr>
<td>Content</td>
<td>- Language conventions and common errors.</td>
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<td></td>
<td>- How to write a thesis (more generally, a mathematics paper).</td>
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<td></td>
<td>- How to use LaTeX.</td>
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<td>- How to write a personal statement for Masters and PhD applications.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>There are no formal mathematical prerequisites.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>401-3502-72L</th>
<th>Reading Course ▪</th>
<th>W</th>
<th>2</th>
<th>4A</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>To start an individual reading course, contact an authorised supervisor.</td>
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<td>401-8571-72L</td>
<td>Differential Forms in Algebraic Topology (University of Zurich)</td>
<td>9</td>
<td>University lecturers</td>
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<td>401-8533-72L</td>
<td>Generalized Complex Geometry (University of Zurich)</td>
<td>3</td>
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<td>Generalized complex geometry is a modern approach to unify complex, symplectic, Poisson and more structures. All these can be formulated as a generalized complex structure, an endomorphism of the sum of the tangent and cotangent bundles ( T+T^* ) that squares to (-1). Alternatively one can encode a generalized complex structure by its ( +1 ) eigenbundle that forms a Dirac structure or as a pure spinor for the Clifford algebra of ( T+T^* ). We will explore ( T+T^* ) with its natural split signature metric, Courant bracket and its symmetries which are an extension of smooth diffeomorphisms. A reduction procedure for Courant algebroids and generalized complex structures generalizes both symplectic reduction and holomorphic reduction of complex manifolds. Subobjects in this category are generalized complex branes. We will see how they mediate between Lagrangian submanifolds with a flat bundle and complex submanifolds with a holomorphic bundle. The deformation theory of generalized complex structures extends the deformation theory of complex and symplectic structures. In this context a ( \text{Kähler} ) structure can be generalized to recover bihermitian geometry discovered by Gates, Hull and Roček. Interesting results and applications include among other topics mirror symmetry and ((2,2)) supersymmetric sigma models. We will see examples of ( \text{generalized Kähler} ) structures on ( \mathbb{CP}^2 ) and on instanton moduli spaces.</td>
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<td></td>
<td>Literature: (Some) Articles: * &quot;Generalized complex geometry&quot; Gualtieri</td>
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<td>&quot;Morita equivalence and the generalized Kähler potential&quot; Bischoff, Gualtieri, Zabzine</td>
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<td></td>
<td>&quot;Lectures on Generalized Complex Geometry and Supersymmetry&quot; Zabzine</td>
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<td></td>
<td>&quot;Reduction of Courant algebroids and generalized complex structures&quot; Bursztyn, Cavalcanti, Gualtieri</td>
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<td>&quot;Generalized Kähler geometry of instanton moduli spaces&quot; Bursztyn, Cavalcanti, Gualtieri</td>
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<td>Prior knowledge: smooth manifolds, complex geometry</td>
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<td>401-8143-72L</td>
<td>Algebraic Topology over a Field (University of Zurich)</td>
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The aim of this course is to give an introduction to A¹-homotopy theory following Morel and Voevodsky. In particular, we will develop enough machinery to understand Morel’s computation of the homotopy groups of spheres in the so-called Milnor range. If time permits, we will also discuss some applications to vector bundles on smooth affine varieties.

Prior Knowledge: Basic knowledge of algebraic geometry (scheme theory) and algebraic topology.

401-8475-22L Microlocal Methods in Dynamical Systems (University of Zurich)
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: MAT644

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

The goal of this course is to introduce the powerful tools of Microlocal Analysis, and to present some striking applications in Chaotic Dynamical Systems.

Understanding the powerful concepts of Microlocal Analysis useful in Analysis and PDEs. Learning about the state-of-the-art applications to Chaotic Dynamical Systems: anisotropic Sobolev spaces, and their applications to Ergodicity and Mixing properties, Zeta Functions.

- Microlocal Analysis studies singularities of distributions in phase space, by describing the behaviour of a singularity in both position and direction. It is a part of the field of partial differential equations (PDE), created by Hoermander, Kohn, Nirenberg, and others in 1960s and 1970s, and is used to study such questions as solvability, regularity, and propagation of singularities of solutions of PDEs. To name a few classical applications: asymptotics of eigenvalues for elliptic operators (Weyl law), trace formulas, and inverse problems.

- There have been recent exciting applications of Microlocal Analysis to Dynamical Systems and Geometry. These range from Dynamical Zeta Functions, Resonances and decay of correlations, to injectivity properties of X-ray (geodesic) transforms, and applications to Rigidity questions in Geometry.

-The goal of this course is to introduce the powerful tools of Microlocal Analysis, and to present some striking applications in Chaotic Dynamical Systems. Here are the details (subject to changes):

1. Distributions and Fourier Transform (recap), Symbol classes and Oscillatory Integrals. Fourier Integral Operators. Stationary Phase Lemma. (3 lectures)
2. Pseudodifferential Operators (PDO). Compositions, changes of coordinates, calculus of PDOs, PDOs on manifolds. (2 lectures)
3. Elliptic regularity, L²-continuity. Sobolev spaces and PDOs. (2 lectures)
4. Wavefront set. Products, pullbacks of distributions. (1 lecture)
5. Applications: 1) construction of anisotropic Sobolev spaces for chaotic dynamics, existence of Pollicott-Ruelle resonances. 2) Ergodicity and Mixing. 3) Possible applications: Ruelle Zeta Function, exponential Mixing for contact Anosov flows, Frame Flows and Parry’s representation. (6 lectures)

The lecturer will provide lecture notes tailored to the course.

-L. Dyatlov, M. Zworski, Dynamical zeta function for Anosov flows via microlocal analysis, Annales de l'ENS, 49(2016), 543--577.
-S. Dyatlov, M. Zworski, Dynamical zeta function for Anosov flows via microlocal analysis, Annales de l'ENS, 49(2016), 543--577.
-

Prior Knowledge: Basic Fourier Analysis and basic knowledge of Distribution Theory are desired, but both will be recalled at the start.

Familiarity to basic differential geometry and functional analysis, but all objects will be recalled.

Electives: Applied Mathematics and Further Application-Oriented Fields

Selection: Numerical Analysis

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<th>Number</th>
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<tr>
<td>401-4657-00L</td>
<td>Numerical Solution of Stochastic Ordinary Differential Equations</td>
<td>W</td>
<td>6 credits</td>
<td>3V+1U</td>
<td>A. Stein</td>
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Alternative course titles: "Numerical Analysis of Stochastic Ordinary Differential Equations" / "Computational Methods for Quantitative Finance: Monte Carlo and Sampling Methods"

This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering.

The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this course the teacher has to follow a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

There will be English, typed lecture notes for registered participants in the course.
Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.

While deep neural networks have been very successfully employed in classification problems, their stability properties remain still unclear.

### 401-4785-00L Mathematical and Computational Methods in Photonics

**Title**: Mathematical and Computational Methods in Photonics

**W**: 8 credits

**4G**: 8 credits

**H. Ammari**

**Objective**

The aim of this course is to review new and fundamental mathematical tools, computational approaches, and inversion and optimal design methods used to address challenging problems in nanophotonics. The emphasis will be on analyzing plasmon resonant nanoparticles, super-focusing & super-resolution of electromagnetic waves, photonic crystals, electromagnetic cloaking, metamaterials, and metasurfaces of the-art for robust image classification, adversarial attacks and adversarial training.

The field of photonics encompasses the fundamental science of light propagation and interactions in complex structures, and its technological applications.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare. Light-based technologies can be used effectively for the very early detection of diseases, with non-invasive imaging techniques or point-of-care applications. They are also instrumental in the analysis of processes at the molecular level, giving a greater understanding of the origin of diseases, and hence allowing prevention along with new treatments. Photonic technologies also play a major role in addressing the needs of our ageing society: from pace-makers to synthetic bones, and from endoscopes to the micro-cameras used in in-vivo processes. Furthermore, photonics are also used in advanced lighting technology, and in improving energy efficiency and quality. By using photonic media to control waves across a wide band of wavelengths, we have an unprecedented ability to fabricate new materials with specific microstructures.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonic crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-mathematics in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena. An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

#### 401-4661-72L Robustness of Deep Neural Networks

**Title**: Robustness of Deep Neural Networks

**W**: 6 credits

**2G+1A**: 6 credits

**R. Alifari**

**Objective**

1. Theory: in this course, we will discuss the trade-off between accuracy and stability of classification algorithms and study the state-of-the-art for robust image classification, adversarial attacks and adversarial training.

2. Practice: students will train and attack deep neural networks themselves, to get a hands-on experience.

**Prerequisites / notice**

Courses on linear algebra, optimization and machine learning. Basic programming skills in Python and experience with PyTorch.

### Selection: Probability Theory, Statistics

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<tr>
<td>401-3628-14L</td>
<td>Bayesian Statistics</td>
<td>W</td>
<td>4</td>
<td>2V</td>
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Does not take place this semester.

**Abstract**

Introduction to the Bayesian approach to statistics; decision theory, prior distributions, hierarchical Bayes models, empirical Bayes, Bayesian tests and model selection, empirical Bayes, Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods.

**Objective**

Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Literature**


Adaptability and Flexibility

M. Dettling

Communication

P. L. Bühlmann

A script will be available.

**Prerequisites / notice**

Familiarity with basic concepts of frequentist statistics and with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

**401-0625-01L Applied Analysis of Variance and Experimental Design**

**Abstract**

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Objective**

Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

**Content**

Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

**Literature**

Faraway (2005): *Linear Models with R*

**Prerequisites / notice**

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

**401-0649-00L Applied Statistical Regression**

**Abstract**

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

**Literature**

Faraway (2005): *Linear Models with R*

Faraway (2006): *Extending the Linear Model with R*


Fox (2008): *Applied Regression Analysis and GLMs*

Montgomery et al. (2006): *Introduction to Linear Regression Analysis*

**Prerequisites / notice**

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

**Fostered competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: not assessed
- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed
- Personal Competencies
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

**401-3627-00L High-Dimensional Statistics**

**Abstract**

"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

**Objective**

Knowledge of methods and basic theory for high-dimensional statistical inference
Content
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

Literature

Prerequisites / notice
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

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<th>Number</th>
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<tr>
<td>401-4623-00L</td>
<td>Time Series Analysis</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>N. Meinshausen</td>
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<tr>
<td>Abstract</td>
<td>The course offers an introduction into analyzing time series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.</td>
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<tr>
<td>Objective</td>
<td>The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.</td>
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<tr>
<td>Content</td>
<td>This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations. The key topics which will be covered as: Stationarity, Autocorrelation, Trend estimation, Elimination of seasonality, Spectral analysis, spectral densities, Forecasting, ARMA, ARIMA, Introduction into GARCH models</td>
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Literature
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

Prerequisites / notice
Basic knowledge in probability and statistics

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<tr>
<td>401-3612-00L</td>
<td>Stochastic Simulation</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>F. Sigrist</td>
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<tr>
<td>Abstract</td>
<td>This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.</td>
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<tr>
<td>Objective</td>
<td>Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.</td>
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Lecture notes
A script will be available in English.

Literature

Prerequisites / notice
Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

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<tbody>
<tr>
<td>401-4607-68L</td>
<td>Topics on the Gaussian Free Field</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>W. Werner</td>
</tr>
<tr>
<td>Abstract</td>
<td>We will discuss various aspects and properties of the Gaussian Free Field. Topics discussed will include: - Discrete and continuous Gaussian Free Field - Local sets. - Relation to loop-soups. - Uniform spanning trees.</td>
<td></td>
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<tr>
<td>Content</td>
<td>- Discrete and continuous Gaussian Free Field - Local sets. - Relation to loop-soups. - Uniform spanning trees.</td>
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<tr>
<td>401-4597-67L</td>
<td>Random Walks on Transitive Graphs</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>V. Tassion</td>
</tr>
<tr>
<td>Abstract</td>
<td>In this course, we will present modern topics at the interface between probability and geometric group theory. We will be mainly focused on the random walk, and discuss its behavior depending on the geometric properties of the underlying graph.</td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>- Probability Theory. - Basic properties of Markov Chains. - No prerequisite on group theory, all the background will be introduced in class.</td>
<td></td>
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</table>

Selection: Financial and Insurance Mathematics

In the Master's programme in Mathematics (direction Mathematics resp. Applied Mathematics 401-3913-01L Mathematical Foundations for Finance is eligible as an elective course resp. applied elective course, but only if 401-3888-00L Introduction to Mathematical Finance isn't recognised for credits (neither in the Bachelor's nor in the Master's programme). For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensecretariat) after having received the credits.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1754 of 2416
The following topics are treated:
- Collective Risk Modeling
- Individual Claim Size Modeling
- Approximations for Compound Distributions
- Ruin Theory in Discrete Time
- Premium Calculation Principles
- Tarification
- Generalized Linear Models and Neural Networks
- Bayesian Models and Credibility Theory
- Claims Reserving
- Solvency Considerations

Lecture notes
M.V. Wüthrich, Non-Life Insurance: Mathematics & Statistics
http://ssrn.com/abstract=2319328

Literature
M.V. Wüthrich, M. Merz. Statistical Foundations of Actuarial Learning and its Applications
http://ssrn.com/abstract=3822407

Prerequisites / notice
The exams ONLY take place during the official ETH examination period (no semester end exams), and only in person exams (i.e. no remote exams).

This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Prerequisites: knowledge of probability theory, statistics and applied stochastic processes.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Content

401-3922-00L Life Insurance Mathematics
W 4 credits 2V M. Koller

Abstract
The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

401-3928-00L Reinsurance Analytics
\textit{Does not take place this semester.}

Abstract
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, Experience and Exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Objective
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Content
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes.

Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

Lecture notes
Slides and lecture notes will be made available.

Prerequisites / notice
An excerpt of last year's lecture notes is available here: https://sites.google.com/site/philipparbenz/reinsuranceanalytics

Basic knowledge in statistics, probability theory, and actuarial techniques.


### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

### Social Competencies

- Communication: assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

### Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

---

**401-3927-00L Mathematical Modelling in Life Insurance**

**W** 4 credits 2V

**Abstract**

In life insurance, it is essential to have adequate mortality tables, be it for reserving or pricing purposes. The course provides the tools necessary to create mortality tables from scratch. Additionally, we study various guarantees embedded in life insurance products and learn to price them with the help of stochastic models.

**Objective**

The course's objective is to provide the students with the understanding and the tools to create mortality tables on their own. Additionally, students should learn to price embedded options in life insurance. Aside of the mere application of specific models, they should develop an intuition for the various drivers of the value of these options.

**Content**

Following main topics are covered:

1. Guarantees and options embedded in life insurance products.
   - Stochastic valuation of participating contracts
   - Stochastic valuation of Unit Linked contracts

2. Mortality Tables:
   - Determining raw mortality rates
   - Smoothing techniques: Whittaker-Henderson, smoothing splines,...
   - Trends in mortality rates
   - Stochastic mortality model due to Lee and Carter
   - Neural Network extension of the Lee-Carter model
   - Integration of safety margins

---

**Lecture notes**

Lectures notes and slides will be provided

**Prerequisites / notice**

The exams ONLY take place during the official ETH examination period. The course counts towards the diploma of “Aktuar SAV”.

Good knowledge in probability theory and stochastic processes is assumed. Some knowledge in financial mathematics is useful.

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**401-3931-00L Responsible Machine Learning with Insurance Applications**

W 4 credits 2G

**Abstract**

This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

**Objective**

The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

**Content**

- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

**Prerequisites / notice**

This course will be held in English and counts towards the diploma of “Aktuar SAV”. For the latter, see details under www.actuaries.ch.

Prerequisites: Good knowledge in statistics/probability theory, statistical modelling and the R programming language are assumed.

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**Selection: Mathematical Physics, Theoretical Physics**

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<tr>
<td>402-0843-00L</td>
<td>Quantum Field Theory I</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>R. Renner</td>
</tr>
</tbody>
</table>

**Abstract**

This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity. Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

**Objective**

The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.
This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.

Objectives

- Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.
- Classical statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.
- Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons.
- Identical quantum particles: many body wave functions, second quantization formalism, equation of motion, correlation functions, selected applications, e.g., Bose-Einstein condensate and coherent state, phonons in elastic media and melting.
- One-dimensional interacting systems.
- Phase transitions: mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls' arguments on long-range order.

Literature

- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

Prerequisites

Recommended: Quantum Field Theory I (in parallel)
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas.

Objective
The students will get an overview of various algebraic methods for solving combinatorial problems. We expect them to understand the proof techniques and to use them autonomously on related problems.

Content
Combinatorics is a fundamental mathematical discipline as well as an essential component of many mathematical areas, and its study has experienced an impressive growth in recent years. While in the past many of the basic combinatorial results were obtained mainly by ingenuity and detailed reasoning, the modern theory has grown out of this early stage and often relies on deep, well-developed tools.

One of the main general techniques that played a crucial role in the development of Combinatorics was the application of algebraic methods. The most fruitful such tool is the dimension argument. Roughly speaking, the method can be described as follows. In order to bound the cardinality of a discrete structure A one maps its elements to vectors in a linear space, and shows that the set A is mapped to linearly independent vectors. It then follows that the cardinality of A is bounded by the dimension of the corresponding linear space. This simple idea is surprisingly powerful and has many famous applications.

This course provides a gentle introduction to Algebraic methods, illustrated by examples and focusing on basic ideas and connections to other areas. The topics covered in the class will include (but are not limited to):

- Basic dimension arguments, Spaces of polynomials and tensor product methods, Eigenvalues of graphs and their application, the Combinatorial Nullstellensatz and the Chevalley-Warning theorem. Applications such as: Solution of Kakeya problem in finite fields, counterexample to Borsuk's conjecture, chromatic number of the unit distance graph of Euclidean space, explicit constructions of Ramsey graphs and many others.

The course website can be found at https://moodle-app2.let.ethz.ch/course/view.php?id=15757

Lecture notes
Lectures will be on the blackboard only, but there will be a set of typeset lecture notes which follow the class closely.

Prerequisites / notice
Students are expected to have a mathematical background and should be able to write rigorous proofs.

401-3054-14L

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<td>252-1425-00L</td>
<td>Geometry: Combinatorics and Algorithms</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
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Abstract
This course provides a gentle introduction to the Probabilistic Method, with an emphasis on methodology. We will try to illustrate the main ideas by showing the application of probabilistic reasoning to various combinatorial problems.

Content
The topics covered in the class will include (but are not limited to): linearity of expectation, the second moment method, the local lemma, correlation inequalities, martingales, large deviation inequalities, Janson and Talagrand inequalities and pseudo-randomness.

Literature
- Graph Coloring and the Probabilistic Method, by M. Molloy and B. Reed, Springer, 2002.

401-3055-64L

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<tr>
<td>252-0417-00L</td>
<td>Randomized Algorithms and Probabilistic Methods</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U+4A</td>
</tr>
</tbody>
</table>

Abstract
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks.

Objective
After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content
Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes
Yes.

Literature

Selection: Theoretical Computer Science, Discrete Mathematics

Selection: Further Realms and Some UZH Courses

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 1758 of 2416
Abstract
Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

Objective
Introduction to various mathematical aspects of Data Science.

Content
These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

Lecture notes

Prerequisites / notice
The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity–including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and “227-0434-10L Mathematics of Information” taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

227-0423-00L Neural Network Theory

Abstract Does not take place this semester.

Objective
The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Content
1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Lecture notes
Detailed lecture notes are available on the course web page
https://www.mins.ee.ethz.ch/teaching/nnt/

Prerequisites / notice
This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

401-3504-02L Reading Course (No. 2)

Abstract
To start an individual reading course, contact an authorised supervisor
https://www.ethz.ch/content/dam/ethz/special-interest/mathdepartment/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf
and register your reading course in myStudies.

Abstract
For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

401-3503-72L Reading Course

Abstract
To start an individual reading course, contact an authorised supervisor
https://www.ethz.ch/content/dam/ethz/special-interest/mathdepartment/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf
and register your reading course in myStudies.

Abstract
For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

401-3504-72L Reading Course

Abstract
To start an individual reading course, contact an authorised supervisor
https://www.ethz.ch/content/dam/ethz/special-interest/mathdepartment/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf
and register your reading course in myStudies.

Abstract
For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

401-3502-72L Reading Course

Abstract
To start an individual reading course, contact an authorised supervisor
https://www.ethz.ch/content/dam/ethz/special-interest/mathdepartment/Intranet/Students/Study_Administration/Theses_Reading_Courses/berechtigungsliste.pdf
and register your reading course in myStudies.

Abstract
For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.
For this Reading Course proactive students make an individual agreement with a lecturer to acquire knowledge through independent literature study.

### 263-5300-00L

#### Abstract
This course is aimed at advanced master and doctorate students who want to conduct independent research on theory for modern machine learning (ML). It teaches standard methods in statistical learning theory commonly used to prove theoretical guarantees for ML algorithms. The knowledge is then applied in independent project work to understand and follow-up on recent theoretical ML results.

#### Objective
By the end of the semester students should be able to
- understand a good fraction of theory papers published in the typical ML venues. For this purpose, students will learn common mathematical techniques from statistical learning in the first part of the course and apply this knowledge in the project work
- critically examine recently published work in terms of relevance and find impactful (novel) research problems. This will be an integral part of the project work and involves experimental as well as theoretical questions
- outline a possible approach to prove a conjectured theorem by e.g. reducing to more solvable subproblems. This will be practiced in in-person exercises, homeworks and potentially in the final project
- effectively communicate and present the problem motivation, new insights and results to a technical audience. This will be primarily learned via the final presentation and report as well as during peer-grading of peer talks.

#### Content
This course touches upon foundational methods in statistical learning theory aimed at proving theoretical guarantees for machine learning algorithms. It touches on the following topics
- concentration bounds
- uniform convergence and empirical process theory
- regularization for non-parametric statistics (e.g. in RKHS, neural networks)
- high-dimensional learning
- computational and statistical learnability (information-theoretic, PAC, SQ)
- overparameterized models, implicit bias and regularization

The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

#### Prerequisites / notice
Students should have a very strong mathematical background (real analysis, probability theory, linear algebra) and solid knowledge of core concepts in machine learning taught in courses such as "Introduction to Machine Learning", "Regression"/"Statistical Modelling". In addition to these prerequisites, this class requires a high degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

Students have usually taken a subset of Fundamentals of Mathematical Statistics, Probabilistic AI, Neural Network Theory, Optimization for Data Science, Advanced ML, Statistical Learning Theory, Probability Theory (D-MATH)

#### Fostered competencies
- Subject-specific Competencies: Concepts and Theories
  - assessed
- Method-specific Competencies: Analytical Competencies
  - assessed
- Problem-solving
  - assessed
- Social Competencies: Communication
  - assessed
- Cooperation and Teamwork
  - assessed
- Personal Competencies: Creative Thinking
  - assessed
- Critical Thinking
  - assessed

### 401-8815-72L

#### Mathematical Aspects of Quantum Mechanics (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: MAT631

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

#### Abstract
The course aims at presenting the basic theory of Quantum Mechanics from the mathematical point of view.

#### Objective
After the course students should have learned topics of spectral theory for unbounded operators and the description of simple models of one-particle quantum systems.

#### Content
We will start with the main mathematical tools of QM: the theory of Hilbert spaces and unbounded operators, self-adjoint and unitary operators, and the spectral theorem. The standard axiomatic description of Quantum Mechanics, main motivation behind the above topics, will also be presented and discussed. This will be followed by the analysis of simple models of one-particle systems such as the free particle, the harmonic oscillator, and the hydrogen atom. Further topics as conservation laws and the angular momentum operators will also be discussed.

If time permits, we will also touch more advanced topics, as for example the theory of general Schrödinger operators and the semiclassical approximation.

#### Literature
- Lecture note written by Benjamin Schlein for the course MAT631 Mathematical Aspects of Quantum Mechanics for the Spring Semester 2018
- Schmüdgen – Unbounded Self-adjoint Operators on Hilbert Space
- Teta - A Mathematical Primer on Quantum Mechanics

#### Prerequisites / notice
The prerequisites are real analysis, and linear algebra. Basic knowledge of classical physics, operator theory on Hilbert spaces, and the Fourier transform are helpful but not required.

### 401-8877-72L

#### Introduction to Batalin-Vilkovisky Formalism (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH.

UZH Module Code: MAT774

#### Abstract
Guarantees for Machine Learning

W 7 credits 3V+1U+2A  F. Yang, A. Sanyal

Number of participants limited to 30.

4V

Guarantees for Machine Learning

W 3 credits 2V  University lecturers

Mind the enrolment deadlines at UZH:

https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

Fostered competencies

Subject-specific Competencies: Concepts and Theories
  - assessed
Method-specific Competencies: Analytical Competencies
  - assessed
Social Competencies: Communication
  - assessed
Personal Competencies: Creative Thinking
  - assessed

401-8877-72L

Mathematical Aspects of Quantum Mechanics (University of Zurich)

W 6 credits 4V  University lecturers

401-8815-72L

Mathematical Aspects of Quantum Mechanics (University of Zurich)

W 6 credits 4V  University lecturers
This class will be an introduction to the perturbative path integral for gauge theories in Batalin-Vilkovisky formalism and the associated mathematical concepts, following P. Mïrnïv's lecture notes (available on ArXiv).

Understanding the main problems and concepts associated with the path integral formulation of Quantum Field Theory.


Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.

(2) Near equilibrum dynamics: Linear and Lyapunov stability

(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations

(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.

(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

E lectives (Direction Applied Mathematics MSc Only)

Electives from applied mathematics and further application-oriented fields that are only eligible for credits for the Master's degree in Applied Mathematics.

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<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4 credits</td>
<td>3V+2U</td>
<td>M. Schweizer</td>
</tr>
</tbody>
</table>

Abstract
First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective
Topics to be covered include
- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Ito's formula, Girsanov transformation, Ito's representation theorem
- Black-Scholes formula

Lecture notes
See information on course homepage

Prerequisites / notice
Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitstheorie").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

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<tr>
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<th>Concep ts and Theories</th>
<th>Techniques and Technologies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Problem-solving</th>
<th>Adaptability and Flexibility</th>
<th>Creative Thinking</th>
<th>Critical Thinking</th>
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Application Area

Mind the enrolment deadlines at UZH:
https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html
### Atmospheric Physics

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<tbody>
<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Wernli, L. Papritz</td>
</tr>
</tbody>
</table>

**Abstract**

This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

**Objective**

Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

**Content**

Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic systems - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

**Lecture notes**

Dynamics of large-scale atmospheric flow

**Literature**


### Biology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>636-0017-00L</td>
<td>Computational Biology</td>
<td>W</td>
<td>6</td>
<td>3G+2A</td>
<td>T. Vaughan, C. Magnus, T. Stadler</td>
</tr>
</tbody>
</table>

**Abstract**

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

**Objective**

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylogdynamics inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- epidemiology
- pathogen evolution
- macroevolution of species

**Content**

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

**Lecture notes**

Lecture slides will be available on moodle.

**Literature**

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.

**Prerequisites**

Basic knowledge in linear algebra, analysis, and statistics will be helpful. Programming in R will be required for the project work (compulsory continuous performance assessments). In case you do not have any previous experience with R, we strongly recommend to get familiar with R prior to the semester start. For the D-BSSE students, we highly recommend the voluntary course „Introduction to Programming“, which takes place in Basel before the start of the semester.

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
</tbody>
</table>

**Abstract**

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

**Objective**

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

**Content**

Biological systems have an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label "Systems Biology", focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks. We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

**Lecture notes**

http://www.csb.ethz.ch/education/lectures.html

**Literature**

Evolutionary dynamics is concerned with the mathematical principles according to which life has evolved. This course offers an introduction to mathematical modeling of evolution, including deterministic and stochastic models, with an emphasis on tumor evolution.

The goal of this course is to understand and to appreciate mathematical models and computational methods that provide insight into the evolutionary process in general and tumor evolution in particular. Students should analyze and evaluate models and their application critically and be able to design new models.

Evolution is the one theory that encompasses all of biology. It provides a single, unifying concept to understand the living systems that we observe today. We will introduce several types of mathematical models of evolution to describe gene frequency changes over time in the context of different biological systems, focusing on asexual populations. Viruses and cancer cells provide the most prominent examples of such systems and they are at the same time of great biomedical interest. The course will cover some classical mathematical population genetics and population dynamics, and also introduce several new approaches. This is reflected in a diverse set of mathematical concepts which make their appearance throughout the course, all of which are introduced from scratch. Topics covered include the quasispecies equation, evolution of HIV, evolutionary game theory, evolutionary stability, evolutionary graph theory, tumor evolution, stochastic tunneling, genetic progression of cancer, diffusion theory, fitness landscapes, branching processes, and evolutionary escape.

Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. Understood and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand the notion of risk-taking capability: capital process as a random walk; measures of long-term risk and relation to capital; short-term solvency vs. long-term stability; effect of embedded options and guarantees; interplay between required return and risk-taking capability.

Be able to study empirical properties of financial assets: the Normal hypothesis and the deviations from it; statistical tools for investigating relevant risk and return properties of financial assets; time aggregation properties; be able to conduct analysis of real data for the most important asset classes.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Have an overall view: see the big picture of what asset returns can and cannot contribute to social security; be aware of the most relevant outcomes; know the role of the actuary in the financial risk management process.
Content
For pension insurance and other forms of social insurance, investment returns are an important source of funding. In order to earn these returns, substantial financial risks must be taken, and these risks represent an important threat to financial stability, in the long term and in the short term.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.

Lecture notes
Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

Prerequisites / notice
Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Group</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0537-00L</td>
<td>Resource and Environmental Economics</td>
<td>W 3 credits</td>
<td>2G</td>
<td>L. Bretschger</td>
</tr>
<tr>
<td>363-0503-00L</td>
<td>Principles of Microeconomics</td>
<td>W 3 credits</td>
<td>2G</td>
<td>M. Filippini</td>
</tr>
</tbody>
</table>

Abstract
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

Objective
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

Literature
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
The book can also be used for the course 'Principles of Microeconomics' (Sturm)

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: assessed
- Self-direction and Self-management: not assessed

363-0565-00L Principles of Macroeconomics

W 3 credits 2V J.-E. Sturm

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

Content
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature
The set-up of the course will closely follow the book of

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
363-1021-00L

Monetary Policy

Abstract
The main aim of this course is to analyse the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy and the differences between monetary policy rules and discretionary policy. It will also make connections between theoretical economic concepts and current real world issues.

Objective
This lecture will introduce the fundamentals of monetary economics and explain the working and impact of monetary policy. The main aim of this course is to describe and analyze the goals of monetary policy and to review the instruments available to central banks in order to pursue these goals. It will focus on the transmission mechanisms of monetary policy, the effectiveness of monetary policy actions, the differences between monetary policy rules and discretionary policy, as well as in institutional issues concerning central banks, transparency of monetary authorities and monetary policy in a monetary union framework. Moreover, we discuss the implementation of monetary policy in practice and the design of optimal policy.

Content
For the functioning of today's economy, central banks and their policies play an important role. Monetary policy is the policy adopted by the monetary authority of a country, the central bank. The central bank controls either the interest rate payable on very short-term borrowing or the money supply, often targeting inflation or the interest rate to ensure price stability and general trust in the currency. This monetary policy course looks into today's major questions related to policies of central banks. It provides insights into the monetary policy process using core economic principles and real-world examples.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17629) contains announcements, course information and lecture slides.

Literature
The course will be based on chapters of:

Prerequisites / notice
Basic knowledge in international economics and a good background in macroeconomics.

363-1017-00L

Risk and Insurance Economics

Abstract
The course covers the economics of risk and insurance, in particular the following topics will be discussed:
2) individual decision making under risk
3) models of insurance demand, risk sharing, insurance supply
4) information issues in insurance markets
5) advanced topics in microeconomics and behavioral economics
5) the macroeconomic role of insurers and insurance regulation

Objective
The course introduces students to basic microeconomic models of risk attitudes and highlight the role insurance can – or cannot – play for individuals facing risks.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed
Everyday, we take decisions involving risks. These decisions are driven by our perception of and our appetite for risk. Insurance plays a significant role in people's risk-management strategies.

In the first part of this lecture, we discuss a normative decision concept, Expected Utility theory, and compare it with empirically observed behaviour.

Students then learn about the rationale for individuals to purchase insurance, and for companies to offer it. We derive the optimal level of insurance demand and discuss how it depends on our model's underlying assumptions.

We then discuss the consequences of information asymmetries in insurance markets and the consequences for insurance supply.

Finally, we discuss refinements in decision theory that help account for observed behaviours that don't fit with the basic models of microeconomic theory. For example, we'll explore how behavioural economics can be leveraged by the insurance industry.

Literature

Main literature:
- Handbook of the Economics of Risk and Uncertainty, Volume 1;

Further readings:

References will be given on a topic-by-topic basis during the course.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Problem-solving: assessed

Personal Competencies
- Critical Thinking: assessed

Finance

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>401-8905-00L</td>
<td>Financial Engineering (University of Zurich)</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Does not take place this semester.
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: MFOEC200

Mind the enrolment deadlines at UZH:

Abstract
This lecture is intended for students who would like to learn more on equity derivatives modelling and pricing.

Objective
Quantitative models for European option pricing (including stochastic volatility and jump models), volatility and variance derivatives, American and exotic options.

Content
After introducing fundamental concepts of mathematical finance including no-arbitrage, portfolio replication and risk-neutral measure, we will present the main models that can be used for pricing and hedging European options e.g. Black-Scholes model, stochastic and jump-diffusion models, and highlight their assumptions and limitations. We will cover several types of derivatives such as European and American options, Barrier options and Variance-Swaps. Basic knowledge in probability theory and stochastic calculus is required.
Besides attending class, we strongly encourage students to stay informed on financial matters, especially by reading daily financial newspapers such as the Financial Times or the Wall Street Journal.

Lecture notes
Script.

Prerequisites / notice
Basic knowledge of probability theory and stochastic calculus. Asset Pricing.

401-8913-00L Advanced Corporate Finance I (University of Zurich) | W | 6 credits | 4G | University lecturers |

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
UZH Module Code: MOEC0455

Mind the enrolment deadlines at UZH:

Abstract
This course develops and refines tools for evaluating investments (capital budgeting), capital structure, and corporate securities. The course seeks to deepen students' understanding of the link between corporate finance theory and practice.
This course develops and refines tools for evaluating investments (capital budgeting), capital structure, and corporate securities. With respect to capital structure, we start with the famous Miller and Modigliani irrelevance proposition and then move on to study the effects of taxes, bankruptcy costs, information asymmetries between firms and the capital markets, and agency costs. In this context, we will also study how leverage affects some central financial ratios that are often used in practice to assess firms and their stock. Other topics include corporate cash holdings, the use and pricing of convertible bonds, and risk management. The latter two topics involve option pricing. With respect to capital budgeting, the course pays special attention to tax effects in valuation, including in the estimation of the cost of capital. We will also study payout policy (dividends and share repurchases). The course seeks to deepen students’ understanding of the link between corporate finance theory and practice. Various cases will be assigned to help reach this objective.

### Prerequisites / notice
This course replaces “Advanced Corporate Finance I” (MOEC0288), which will be discontinued from HS16.

#### Image Processing and Computer Vision

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6 credits</td>
<td>3+1U</td>
<td>E. Konukoglu, F. Yu</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content**
This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Lecture notes**
Course material Script, computer demonstrations, exercises and problem solutions

**Prerequisites / notice**
Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

#### Information and Communication Technology

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0105-00L</td>
<td>Introduction to Estimation and Machine Learning</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

**Abstract**
Mathematical basics of estimation and machine learning, with a view towards applications in signal processing.

**Objective**
Students master the basic mathematical concepts and algorithms of estimation and machine learning.

**Content**
Review of probability theory; basics of statistical estimation; least squares and linear learning; Hilbert spaces; singular-value decomposition; kernel methods, neural networks, and more.

**Lecture notes**
Lecture notes will be handed out as the course progresses.

**Prerequisites / notice**
Solid basics in linear algebra and probability theory.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
</tr>
</tbody>
</table>

**Abstract**
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSE estimation and LMMSE filtering, LMS algorithm, Viterbi algorithm.

**Objective**
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSE estimation and LMMSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust “inversion” of a linear filter.
This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equipartition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

The entropy rate of a source, typical sequences, the asymptotic equipartition property, the source coding theorem, Huffman coding, arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Lecture notes Lecture Notes

227-0417-00L Information Theory I W 6 credits 4G A. Lapidoth
Abstract This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equipartition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Objective The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

Content The entropy rate of a source, typical sequences, the asymptotic equipartition property, the source coding theorem, Huffman coding, arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Machine Learning
The list is not yet complete.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>263-3210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The material covered in the course &quot;Introduction to Machine Learning&quot; is considered as a prerequisite.</td>
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</tr>
<tr>
<td>Content</td>
<td>Topics covered:</td>
<td></td>
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</tr>
</tbody>
</table>
- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning |
| Prerequisites / notice| Solid basic knowledge in statistics, algorithms and programming. |

263-3210-00L Deep Learning W 8 credits 3V+2U+2A T. Hofmann, F. Perez Cruz.
Abstract In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Objective The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
Advanced Machine Learning
https://ml2.inf.ethz.ch/courses/aml/
Computational Intelligence Lab
http://da.inf.ethz.ch/teaching/2019/CIL/
Introduction to Machine Learning
https://las.inf.ethz.ch/teaching/introml-S19
Statistical Learning Theory
http://ml2.inf.ethz.ch/courses/slt/
Computational Statistics
https://stat.ethz.ch/lectures/ss19/comp-stats.php
Probabilistic Artificial Intelligence
https://las.inf.ethz.ch/teaching/pai-118

252-3005-00L Natural Language Processing W 7 credits 3V+3U+1A R. Cotterell
Number of participants limited to 400.
Abstract This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used in both research and in commercial natural language systems.

Objective The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.
Content
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

263-5255-00L Foundations of Reinforcement Learning
Does not take place this semester.
Number of participants limited to 190.

Abstract
Reinforcement learning (RL) has been in the limelight of many recent breakthroughs in artificial intelligence. This course focuses on theoretical and algorithmic foundations of reinforcement learning, through the lens of optimization, modern approximation, and learning theory. The course targets M.S. students with strong research interests in reinforcement learning, optimization, and control.

Objective
This course aims to provide students with an advanced introduction of RL theory and algorithms as well as bring them near the frontier of this active research field.

By the end of the course, students will be able to
- Identify the strengths and limitations of various reinforcement learning algorithms;
- Formulate and solve sequential decision-making problems by applying relevant reinforcement learning tools;
- Generalize or discover "new" applications, algorithms, or theories of reinforcement learning towards conducting independent research on the topic.

Content
Basic topics include fundamentals of Markov decision processes, approximate dynamic programming, linear programming and primal-dual perspectives of RL, model-based and model-free RL, policy gradient and actor-critic algorithms, Markov games and multi-agent RL. If time allows, we will also discuss advanced topics such as batch RL, inverse RL, causal RL, etc. The course keeps strong emphasis on in-depth understanding of the mathematical modeling and theoretical properties of RL algorithms.

Lecture notes
Lecture notes will be posted on Moodle.

Literature
Dynamic Programming and Optimal Control, Vol I & II, Dimitris Bertsekas
Algorithms for Reinforcement Learning, Csaba Czepesvári.

Prerequisites
Students are expected to have strong mathematical background in linear algebra, probability theory, optimization, and machine learning.

Material Modelling and Simulation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>327-1201-00L</td>
<td>Transport Phenomena I</td>
<td>W</td>
<td>5 credits</td>
<td>4G</td>
<td>J. Vermant</td>
</tr>
</tbody>
</table>

Abstract
Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

Objective
The teaching goals of this course are on five different levels:
(1) Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling, ...
(2) Ability to use the fundamental concepts in applications
(3) Insight into the role of boundary conditions (mainly part 2)
(4) Knowledge of a number of applications.
(5) Flavor of numerical techniques: finite elements and finite differences.

Content
Part I Approach to Transport Phenomena
Equilibrium Thermodynamics
Balance Equations
Forces and fluxes
Applications
1. Measuring Transport Coefficients
2. Fluid mechanics
3. Combined heat and flow

Material Chemistry

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<tr>
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<tr>
<td>529-0003-01L</td>
<td>Advanced Quantum Chemistry</td>
<td>W</td>
<td>6 credits</td>
<td>3G</td>
<td>M. Reiher, A. Baiardi</td>
</tr>
</tbody>
</table>

Abstract
Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer.
Examples are:
- Operators derived from principles of relativistic quantum mechanics
- Relativistic effects + methods of relativistic quantum chemistry
- Open-shell molecules + spin-density functional theory
- New electron-correlation theories
Objective

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

Content

1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group
9) Quantum chemistry without the Born-Oppenheimer approximation

Lecture notes

A set of detailed lecture notes will be provided, which will cover the whole course.

Literature

2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992
8) Note also the standard textbooks:
   A) A. Szabo, N.S. Ostlund, Molecular Quantum Chemistry, Dover Publications
   B) I. N. Levine, Quantum Chemistry, Pearson

Prerequisites / notice

Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

Systems Design

"Simulation of Semiconductor Devices" is no longer offered as an application area.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | 
363-0541-00L | Systems Dynamics and Complexity | W | 3 credits | 3G | F. Schweitzer

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption

A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics
Theoretical Physics

In the Master's programme in Applied Mathematics 402-0205-00L Quantum Mechanics I is eligible as a course unit in the application area Theoretical Physics, but only if 402-0224-00L Theoretical Physics wasn't or isn't recognised for credits (neither in the Bachelor's nor in the Master's programme).

For the category assignment take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Number Title Type ECTS Hours Lecturers
402-0809-00L Introduction to Computational Physics W 8 credits 2V+2U A. Adelmann
Abstract This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.
Objective Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.
Content Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.
Lecture notes Literature Lecture notes and slides are available online and will be distributed if desired.
Prerequisites / notice Lecture notes and slides are available online and will be distributed if desired.

402-2203-01L Classical Mechanics W 7 credits 4V+2U M. Gaberdiel
Abstract A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.
Objective Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.

402-0861-00L Statistical Physics W 10 credits 4V+2U E. Demler
Abstract This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.
Objective This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.

402-0843-00L Quantum Field Theory I W 10 credits 4V+2U R. Renner
Special Students UZH must book the module PHY551 directly at UZH.
Abstract
This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity.
Topics include:
- Relativistic quantum mechanics
- Quantisation of bosonic and fermionic fields
- Interactions in perturbation theory
- Scattering processes and decays
- Elementary processes in QED
- Radiative corrections

Objective
The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.

Lecture notes
Will be provided as the course progresses

Electives Theoretical Physics

402-0830-00L General Relativity
Special Students UZH must book the module PHYS11 directly at UZH.

Abstract
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.

Objective
Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.

Content
Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).

Literature
Suggested textbooks:
- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

Transportation Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
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</tr>
</thead>
<tbody>
<tr>
<td>101-0417-00L</td>
<td>Transport Planning Methods</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>K. W. Axhausen</td>
</tr>
</tbody>
</table>

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehending the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

Content
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Lecture notes
Moodle platform (enrollment needed)
Seminars and Semester Papers

NOTICE: The number of seminar places is limited, and the special selection procedure should help to allocate the places not primarily according to the registration time. Everybody is waitlisted first when he/she tries to register for a seminar in myStudies. Moreover: Only one mathematics seminar can be chosen per semester. In case you need to attend 2 seminars in this semester, please take contact with the Study Administration (email: studiensekretariat@math.ethz.ch). 

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>401-3650-72L</td>
<td>Rational Approximation and Interpolation</td>
<td>W</td>
<td>4 credits</td>
<td>2S</td>
<td>R. Hiptmair</td>
</tr>
<tr>
<td>Abstract</td>
<td>The seminar covers theory and algorithms for rational interpolation based on classical and modern literature. The various topics have to be presented by groups of students.</td>
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<tr>
<td>Objective</td>
<td>Participants of the seminar should acquire familiarity with the theoretical properties of approximation by means of rational functions as well as knowledge about algorithms used for computing approximating or interpolating rational functions.</td>
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<tr>
<td>Content</td>
<td>The simplest and most widely used function system for approximation in computational mathematics are polynomials. They are ideally suited for smooth (analytic) functions. However, in many application we encounter functions with kinks and other kinds of singularities. In this case approximation by rational functions, that is, quotients of polynomials, may be vastly superior. This is why rational approximation and interpolation is receiving increased attention for the construction of surrogate models in model order reduction.</td>
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<tr>
<td>Literature</td>
<td>Will be announced in due course</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Good skills in analysis are required as well as basic familiarity with numerical methods for interpolation and approximation with polynomials.</td>
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<tr>
<td>Preparatory meeting</td>
<td>Mon, Sep 19, 2022, 18:00 on ZOOM, Meeting ID: 698 4220 0325, Password: RAP HS22</td>
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<tr>
<td>Every presentation has to be done jointly by a group of 2-3 students with presenters selected at random. Every participant will have to present on 2-3 occasions.</td>
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</table>

| 401-3550-72L | Topology and Combinatorics of Zero Sets of Polynomials in the Plane      | W    | 4 credits | 2S   | P. Feller |
| Abstract | The seminar consists of student presentations on topics from "A Singular Mathematical Promenade" written by Étienne Ghys. |
| Objective | Understanding different aspects of the combinatorics of zerosets of polynomials as presented in "A Singular Mathematical Promenade" written by Étienne Ghys. |
| Content | See https://metaphor.ethz.ch/x/2022/hs/401-3550-72L/ |
| Literature | "A singular mathematical promenade" by Étienne Ghys. |
| Prerequisites / notice | Requirements (beyond first year Bachelor courses): |
| - One semester introduction to complex analysis (as provided by D-Math's "Funktionentheorie") |
| - One semester introduction to topology (as provided by D-Math's "Topologie") |

| 401-3620-20L | Student Seminar in Statistics: Inference in Some Non-Standard Regression Problems | W    | 4 credits | 2S   | F. Balabdaoui |
| Abstract | Review of some non-standard regression models and the statistical properties of estimation methods in such models. |
| Objective | The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models). |
The seminar will consist of student presentations and will cover a variety of topics in modern-day combinatorics. The seminar is aimed at introducing students to interesting results, proofs, and techniques in combinatorics and graph theory, and to giving them the opportunity to work with advanced research papers and practice their presentation skills.

Semesters Papers

There are several course units "Semester Paper" that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>401-3350-72L</td>
<td>Elliptic Partial Differential Equations</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>F. Da Lio, L. Kobel-Keller</td>
</tr>
<tr>
<td>401-4350-72L</td>
<td>Introduction to Partial Differential Equations</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>A. Rege</td>
</tr>
<tr>
<td>401-3760-72L</td>
<td>Topics in Fluid Dynamics</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>H. Kwon</td>
</tr>
<tr>
<td>401-3940-72L</td>
<td>Student Seminar in Mathematics and Data: Differential</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>A. Bandeira, M. T. Boedihardjo</td>
</tr>
<tr>
<td>401-3050-72L</td>
<td>Student Seminar in Combinatorics</td>
<td>W</td>
<td>4</td>
<td>2S</td>
<td>B. Sudakov</td>
</tr>
</tbody>
</table>

Prerequisites

- The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

Objective

- The seminar's aim is to acquaint students with interesting results, proofs and techniques in combinatorics and graph theory, and to give them the opportunity to work with advanced research papers and practice their presentation skills.

Content

Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, linearity might be too simplistic to capture the actual relationship between some response and given covariates. Also, there are many real data problems where linearity is plausible but the actual pairing between the observed covariates and responses is completely lost or at partially. In this seminar, we review some of the non-classical regression models and the statistical properties of the estimation methods considered by well-known statisticians and machine learners. This will encompass:

1. Monotone regression
2. Single index model
3. Unlinked regression

Literature

In the following is the tentative material that will be read and studied by each pair of students (all the items listed below are available through the ETH electronic library or arXiv). Some of the items might change:

8. "Linear regression with shuffled data: statistical and computation limits of permutation recovery" by A. Pananjady, M. Wainwright and T. A. Courtade, 2018, IEEE transactions in Information Theory, Volume 64, 3286-3300
9. "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS
11. "Uncoupled-likelihood approach to linear regression via minimum Wasserstein deconvolution" by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27

Abstract

- The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

References

2. "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS

Abstract

The seminar's aim is to acquaint students with interesting results, proofs and techniques in combinatorics and graph theory, and to give them the opportunity to work with advanced research papers and practice their presentation skills.

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<td>B. Sudakov</td>
</tr>
</tbody>
</table>

Prerequisites

- The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

Objective

- The seminar's aim is to acquaint students with interesting results, proofs and techniques in combinatorics and graph theory, and to give them the opportunity to work with advanced research papers and practice their presentation skills.

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Prerequisites / notice

There are several course units "Semester Paper" that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.

401-3750-03L Semester Paper (No. 3) W 8 credits 11A Supervisors

Abstract

Semester Papers help to deepen the students' knowledge of a specific subject area. Students are offered a selection of topics. These papers serve to develop the students' ability for independent mathematical work as well as to enhance skills in presenting mathematical results in writing.

Prerequisites / notice

There are several course units "Semester Paper" that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.

Science in Perspective

Two credits are needed from the "Science in Perspective" programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree. (Eight credits must be acquired in this category: normally six during the Bachelor's degree programme, and two during the Master's degree programme. A maximum of three credits from language courses from the range of the Language Center of the University of Zurich and ETH Zürich may be recognised. In addition, only advanced courses (level B2 upwards) in the European languages English, French, Italian and Spanish are recognised. German language courses are recognised from level C2 upwards.)

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MATH

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Mathematics</td>
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<td>D. Possamai</td>
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<td>Third year Bachelor students;</td>
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<td>Introduction to scientific writing for students</td>
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<td>with focus on publication standards and ethical</td>
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<td>Learn the basic standards of scientific works</td>
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401-2000-01L Lunch Sessions – Thesis Basics for Mathematics Students Z 0 credits Speakers

Abstract

Details and registration for the optional MathBib training course: https://www.math.ethz.ch/mathbib-schulungen

401-4990-00L Master's Thesis O 30 credits 57D Supervisors

Only students who fulfill the following criteria are allowed to begin with their Master's thesis:

a. successful completion of the Bachelor's programme;

b. fulfilling of any additional requirements necessary to gain admission to the Master's programme.

Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics is required.

For more information, see www.math.ethz.ch/intranet/students/study-administration/theses.html

Abstract

The master's thesis concludes the study programme. Writing up the master's thesis allows students to independently produce a major piece of work on a mathematical topic. It generally involves consulting the literature, solving any ensuing problems, and putting together the results in writing.

Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>401-5000-00L</td>
<td>Zurich Colloquium in Mathematics</td>
<td>E-</td>
<td>0</td>
<td></td>
<td>R. Abgrall, M. Iacobelli, A. Bandeira, A. Iozzi, S. Mishra, R. Pandharipande, University lecturers</td>
</tr>
</tbody>
</table>

401-5990-00L Zurich Graduate Colloquium E- 0 credits 1K A. Iozzi, further speakers

Abstract

The Graduate Colloquium is an informal seminar aimed at graduate students and postdocs whose purpose is to provide a forum for communicating one's interests and thoughts in mathematics.

401-4530-00L Geometry Graduate Colloquium E- 0 credits 1K Speakers

401-5110-00L Number Theory Seminar E- 0 credits 1K Ö. Imamoglu, E. Kowalski, R. Pink, G. Wüstholz, S. Zerbes
<table>
<thead>
<tr>
<th>Registration Code</th>
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<th>Credits</th>
<th>Event Language</th>
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<tr>
<td>401-5350-00L</td>
<td>Research colloquium</td>
<td>Analysis Seminar</td>
<td>0</td>
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<td>F. Da Lio, A. Figalli, N. Hungerbühler, M. Iacobelli, T. Ilmanen, L. Kobel-Keller, T. Rivièr, J. Serra, University lecturers</td>
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<tr>
<td>401-5370-00L</td>
<td>Research colloquium</td>
<td>Ergodic Theory and Dynamical Systems</td>
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<td>401-5530-00L</td>
<td>Research colloquium</td>
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<td>401-5580-00L</td>
<td>Research colloquium</td>
<td>Symplectic Geometry Seminar</td>
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<tr>
<td>401-5330-00L</td>
<td>Research colloquium</td>
<td>Talks in Mathematical Physics</td>
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<td>A. Cattaneo, G. Felder, M. Gaberdiel, G. Graf, P. Hintz, T. H. Willwacher</td>
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<tr>
<td>401-5650-00L</td>
<td>Research colloquium</td>
<td>Zurich Colloquium in Applied and Computational Mathematics</td>
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<td>R. Abgrall, R. Alaiifhari, H. Ammari, R. Hiptmair, S. Mishra, S. Sauter, C. Schwab</td>
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<td>401-5600-00L</td>
<td>Research colloquium</td>
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<td>Foundations of Data Science Seminar</td>
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<td>401-5910-00L</td>
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<td>Talks in Financial and Insurance Mathematics</td>
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<td>401-5960-00L</td>
<td>Research colloquium</td>
<td>Colloquium on Mathematics, Computer Science, and Education</td>
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<tr>
<td>402-0101-00L</td>
<td>Research colloquium</td>
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<tr>
<td>402-0800-00L</td>
<td>Research colloquium</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>0</td>
<td>1</td>
<td>J. Renes, University lecturers</td>
</tr>
<tr>
<td>251-0100-00L</td>
<td>Research colloquium</td>
<td>Computer Science Colloquium</td>
<td>0</td>
<td>2</td>
<td>Lecturers</td>
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</tbody>
</table>
Invited talks, covering the entire scope of computer science. External Listeners are welcome at no charge. A detailed schedule is published at the beginning of each semester.

Objective
Top international computer scientists take the floor at the distinguished computer science colloquium. Our guest speakers present impacting topics across various areas of the discipline. The colloquium series is held every semester and also includes inaugural and farewell lectures of the department's professors. The colloquium is a noteworthy event for all graduate students. Outside attendance is equally welcome.

Content
Renowned international computer scientists take the floor at our distinguished colloquium series, to present topics across all areas of computer science.

► Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>
| 406-2004-AAL | Algebra II  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.  
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit. | E-    | 5 credits | 11R   | L. Halbeisen  |
| 406-2005-AAL | Algebra I and II  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.  
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit. | E-    | 12 credits | 26R   | L. Halbeisen  |
| 406-2303-AAL | Complex Analysis  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.  
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit. | E-    | 6 credits  | 13R   | E. Kowalski   |
| 406-2284-AAL | Measure and Integration  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.  
Any other students (e.g. incoming exchange students, | E-    | 6 credits  | 13R   | T. H. Willwacher |

Abstract
Galois theory and related topics.

Objective
Introduction to fundamentals of field extensions, Galois theory, and related topics.

Content
The main topic is Galois Theory. Starting point is the problem of solvability of algebraic equations by radicals. Galois theory solves this problem by making a connection between field extensions and group theory. Galois theory will enable us to prove the theorem of Abel-Ruffini, that there are polynomials of degree 5 that are not solvable by radicals, as well as Galois' theorem characterizing those polynomials which are solvable by radicals.

Literature

Galois Theory is the topic treated in Chapter A5.

Prerequisites / notice
Algebra I, in Rotman's book this corresponds to the topics treated in the Chapters A3 and A4.

Abstract
Introduction and development of some basic algebraic structures - groups, rings, fields including Galois theory, representations of finite groups, algebras.

Objective
The precise content changes with the examiner. Candidates must therefore contact the examiner in person before studying the material.

Content
Basic notions and examples of groups;
- Subgroups, Quotient groups and Homomorphisms, Group actions and applications
- Basic notions and examples of rings;
- Ring Homomorphisms, ideals, and quotient rings, rings of fractions
- Euclidean domains, Principal ideal domains, Unique factorization domains
- Basic notions and examples of fields;
- Field extensions, Algebraic extensions, Classical straight edge and compass constructions
- Fundamentals of Galois theory
- Representation theory of finite groups and algebras

Literature
### Abstract
Introduction to the abstract measure theory and integration, including the following topics: Lebesgue measure and Lebesgue integral, $L^p$-spaces, convergence theorems, differentiation of measures, product measures, integration, abstract measures, Radon-Nikodym theorem, probabilistic language.

### Objective
Basic acquaintance with the theory of measure and integration, in particular, Lebesgue's measure and integral.

### Literature
1. Lecture notes by Professor Michael Struwe (http://www.math.ethz.ch/~struwe/Skripten/AnalysisIII-SS2007-18-4-08.pdf)
2. L. Evans and R.F. Gariepy “Measure theory and fine properties of functions”
3. Walter Rudin “Real and complex analysis”
4. R. Bartle The elements of Integration and Lebesgue Measure

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### 406-2554-AAL
**Topology**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Topological spaces, continuous maps, connectedness, compactness, metric spaces, quotient spaces, homotopy, fundamental group and covering spaces, van Kampen Theorem.

**Literature**
- James Munkres: Topology

**Prerequisites / notice**
The precise content changes with the examiner. Candidates must therefore contact the examiner in person before studying the material.

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### 406-2604-AAL
**Probability and Statistics**

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
Introduction to probability and statistics with many examples, based on chapters from the books "Probability and Random Processes" by G. Grimmett and D. Stirzaker and "Mathematical Statistics and Data Analysis" by J. Rice.

**Objective**
The goal of this course is to provide an introduction to the basic ideas and concepts from probability theory and mathematical statistics. In addition to a mathematically rigorous treatment, also an intuitive understanding and familiarity with the ideas behind the definitions are emphasized. Measure theory is not used systematically, but it should become clear why and where measure theory is needed.

**Content**
- Probability: Chapters 1-5 (Probabilities and events, Discrete and continuous random variables, Generating functions) and Sections 7.1-7.5 (Convergence of random variables) from the book "Probability and Random Processes". Most of this material is also covered in Chap. 1-5 of "Mathematical Statistics and Data Analysis", on a slightly easier level.

**Literature**

---

**Mathematics Master - Key for Type**

| O | Compulsory |
| W+ | Eligible for credits and recommended |
| W | Eligible for credits |

**Key for Hours**

| V | lecture |
| G | lecture with exercise |
| U | exercise |
| S | seminar |
| K | colloquium |

| P | practical/laboratory course |
| A | independent project |
| D | diploma thesis |
| R | revision course / private study |

**ECTS**
European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.

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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1779 of 2416
### Devices and Systems

#### Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0166-00L</td>
<td>Analog Integrated Circuits</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>T. Jang</td>
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</table>

**Abstract**

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies.

**Objective**

Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

**Content**

- Review of bipolar and MOS devices and their small-signal equivalent circuit models.
- Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing.
- Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps, stability, comparators.
- Second-order effects in analog circuits such as mismatch, noise and offset.
- Data converters, frequency synthesizers, switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

**Lecture notes**

Handouts of presented slides. No script but an accompanying textbook is recommended.

**Literature**


#### Energy Conversion and Quantum Phenomena

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<th>Lecturers</th>
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<tr>
<td>151-0913-00L</td>
<td>Introduction to Photonics</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>R. Quidant, J. Ortega Arroyo</td>
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</table>

**Abstract**

This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

**Objective**

Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practise. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polarisation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Anti-reflection coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Lecture notes
Class notes and handouts

Literature
Optics (Hecht) - Pearson

Prerequisites / notice
Physics I, Physics II

402-0468-15L Nanomaterials for Photonics W 6 credits 2V+1U R. Grange

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.
1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes
Slides and book chapter will be available for downloading

Literature
References will be given during the lecture

Prerequisites / notice
Basics of solid-state physics (i.e. energy bands) can help

Semiconductor Nanostructures

- The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

- At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
  1. The integer quantum Hall effect
  2. Conductance quantization in quantum point contacts
  3. the Aharonov-Bohm effect
  4. Coulomb blockade in quantum dots
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Prerequisites / notice
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Lecture notes
In addition to the lecture notes, the following supplementary books can be recommended:


Prerequisites
The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequist. Very ambitioned students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

Material, Surfaces and Properties

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
151-0509-00L | Acoustics in Fluid Media: From Robotics to Additive Manufacturing | W | 4 credits | 3G | D. Ahmed

Abstract
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

Lecture notes

Literature

151-0524-00L | Continuum Mechanics I | W- | 4 credits | 2V+1U | A. E. Ehret

Abstract
The lecture deals with constitutive models that are relevant for the design and analysis of structures. These include anisotropic linear elasticity, linear viscoelasticity, plasticity and viscoplasticity. The basic concepts of homogenization and laminate theory are introduced. Theoretical models are complemented by examples of engineering applications and experiments.

Objective
Basic theories for solving continuum mechanics problems of engineering applications, with particular focus on constitutive models.
The course objectives are best met primarily through the individual student projects which may involve experiments, simulations or critical 

Particles are everywhere and nano is the new scale in science & engineering as micro was ~200 years ago. For highly motivated students, 

2V+2U  

yes  

Surfaces, Interfaces and their Applications I  

S. E. Pratsinis, V. Mavrantzas, K. Wegner  

To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to 

3 credits  

2V+1U  

Introduction to Surface Science  

Script Download: 

https://moodle-app2.let.ethz.ch/course/view.php?id=17455  


Anisotropic elasticity, Linear elastic and linear viscous material behavior, Viscoelasticity, Micro-macro modelling, Laminate theory, 

Plasticity, Viscoelasticity, Examples of engineering applications, Comparison with experiments  

Lecture notes  

yes  

151-0902-00L Micro- and Nanoparticle Technology  

W 6 credits  

2V+2U  

S. E. Pratsinis, V. Mavrantzas, K. Wegner  

Abstract  

Objects are everywhere and nano is the new scale in science & engineering as micro was ~200 years ago. For highly motivated students, 

Objective  

This course aims to familiarize motivated M/BSc students with some of the basic phenomena of particles at the nanoscale, thereby 

illustrating the links between physics, chemistry, materials science through hands-on experience. Furthermore it aims to give an overview 

of the field with motivating lectures from industry and academia, including the development of technologies and processes based on 

particle technology with introduction to design methods of mechanical processes, scale-up laws and optimal use of materials and energy. 

Most importantly, this course aims to develop the creativity and sharpen the communication skills of motivated students through their 

individual projects, a PERFECT preparation for the M/BSc thesis (e.g. efficient & critical literature search, effective oral/written project 

presentations), the future profession itself and even life, in general, are always there! 

Content  

The course objectives are best met primarily through the individual student projects which may involve experiments, simulations or critical 

& quantitative reviews of the literature. Projects are conducted individually under the close supervision of MSc, PhD or post-doctoral 

students. Therein, a 2-page proposal is submitted within the first two semester weeks addressing explicitly, at least, 10 well-selected 

research articles and thoughtful meetings with the project supervisor. The proposal address 3 basic questions: a) how important is the 

project; b) what has been done already in that field and c) what will be done by the student. Detailed feedback on each proposal is given by 

the supervisor, assistant and professor two weeks later. Towards the end of the semester, a 10-minute oral presentation is given by the 

student followed by 10 minutes Q&A. A 10-page final report is submitted by noon of the last day of the semester. The project supervisor will 

provide guidance throughout the course. Lectures include some of the following: 

- Overview & Project Presentation 
- Particle Size Distribution 
- Particle Diffusion 
- Coagulation 
- Agglomeration & Coalescence 
- Particle Growth by Condensation 
- Control of particle size & structure during gas-phase synthesis 
- Multi-scale design of aerosol synthesis of particles 
- Particle Characterization 
- Aerosol manufacture of nanoparticles 
- Forces acting on Single Particles in a Flow Field 
- Fixed and Fluidized Beds 
- Separations of Solid-Liquid & Solid-Gas systems 
- Emulsions/droplet formation/microfluidics 
- Gas Sensors 
- Coaching for proposal & report writing as well as oral presentations 

Literature  


History of the Manufacture of Fine Particles in High-Temperature Aerosol Reactors in Aerosol Science and Technology: History and 


Prerequisites / 

notice  

FluidMechanik I, Thermodynamik I & II & “clean” 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As extra pull effort will be required! Having seen “Chasing Mavericks” (2012) by Apted & Henson, “Unbroken” (2014) by Angelina Jolie and, 

in particular, “The Salt of the Earth” (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic 

effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or 

merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during 

WWII)). 

327-0505-00L Surfaces, Interfaces and their Applications I  

W 3 credits  

2V+1U  

N. Spencer, M. P. Heuberger, L. Isa  

Abstract  

After being introduced to the physical/chemical principles and importance of surfaces and interfaces, the student is introduced to the most 

important techniques that can be used to characterize surfaces. Later, liquid interfaces are treated, followed by an introduction to the fields 

of tribology (friction, lubrication, and wear) and corrosion. 

Objective  

To gain an understanding of the physical and chemical principles, as well as the tools and applications of surface science, and to be able to 

choose appropriate surface-analytical approaches for solving problems. 

Content  

Introduction to Surface Science 

Physical Structure of Surfaces 

Surface Forces (static and dynamic) 

Adsorbates on Surfaces 

Surface Thermodynamics and Kinetics 

The Solid-Liquid Interface 

Electron Spectroscopy 

Vibrational Spectroscopy on Surfaces 

Scanning Probe Microscopy 

Introduction to Tribology 

Introduction to Corrosion Science 

Lecture notes  

Script Download: 

https://moodle-app2.let.ethz.ch/course/view.php?id=17455  

Surfaces, Interfaces and their Applications I  

W 3 credits  

2V+1U  

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Abstract  

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Electron Spectroscopy 

Vibrational Spectroscopy on Surfaces 

Scanning Probe Microscopy 

Introduction to Tribology 

Introduction to Corrosion Science 

Lecture notes  

Script Download: 

https://moodle-app2.let.ethz.ch/course/view.php?id=17455  


Prerequisites / 

notice  

Chemistry: 

General undergraduate chemistry 

including basic chemical kinetics and thermodynamics 

Physics: 

General undergraduate physics 

including basic theory of diffraction and basic knowledge of crystal structures 

Data: 01.11.2022 12:41  

Autumn Semester 2022  

Page 1784 of 2416
Modelling and Simulation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering. With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

Content
1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Prerequisites / notice
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

Laboratory Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0602-00L</td>
<td>Embedded MEMS Lab</td>
<td>W+</td>
<td>5</td>
<td>3P</td>
<td>C. Hierold, M. Haluska</td>
</tr>
</tbody>
</table>

Abstract
Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access

Objective
Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.

Content
With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:
- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures
- Packaging and electrical connection of a MEMS device
- Testing and characterization of the MEMS device
- Written documentation and evaluation of the entire production, processing and characterization

Lecture notes
A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.

Literature
The document provides sufficient information for the participants to successfully participate in the course.
As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

The course comes in a variety of lecture and computer lab settings. Participating students are required to attend all scheduled lectures and meetings of the course. For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:

Priority 1: master students of the master's program in "Micro and Nanosystems"
Priority 2: master students of the master's program in "Mechanical Engineering" with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Danai, Duel, Hierold, Koumoutsakos, Norsø, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
Priority 3: master students, who attended the bachelor course "151-0621-00L Microsystems Technology" successfully.
Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.

If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots. Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate. The course is offered in autumn and spring semester.

### Elective Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0409-00L</td>
<td>Multiphysics Modeling and Simulation</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>C. I. Roman</td>
</tr>
</tbody>
</table>

**Abstract**

This course introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

**Objective**

As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling. Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

**Content**

- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

**Lecture notes**

Lecture handouts will be posted online.

**Fostered competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Reflection: assessed
- Self-direction and Self-management: assessed

**151-0525-00L Dynamic Behavior of Materials**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0525-00L</td>
<td>Dynamic Behavior of Materials</td>
<td>W</td>
<td>4</td>
<td>2V+2U</td>
<td>T. Tancogne-Dejean, C. Roth</td>
</tr>
</tbody>
</table>

**Abstract**

Lectures and computer labs concerned with the modeling of the deformation response and failure of engineering materials (metals, polymers and composites) subject to extreme loadings during manufacturing, crash, impact and blast events. Students will learn to apply, understand and develop computational models of a large spectrum of engineering materials to predict their dynamic deformation response and failure in finite element simulations. Students will become familiar with important dynamic testing techniques to identify material model parameters from experiments. The ultimate goal is to provide the students with the knowledge and skills required to engineer modern multi-material solutions for high performance structures in automotive, aerospace and naval engineering.
Familiarize students with main architectural principles and concepts of embedded control systems.

Lecture notes: Slides of the lectures, relevant journal papers and user manuals will be provided.

Prerequisites / notice: Course in continuum mechanics (mandatory), finite element method (recommended)

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Communication</td>
<td>not assessed</td>
<td></td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
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</tbody>
</table>

**151-0532-00L Nonlinear Dynamics and Chaos I**

**Abstract**
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

**Objective**
This course is intended for Masters and Ph.D. students in engineering sciences, physics, and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

**Content**
1. Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
2. Near equilibrium dynamics: Linear and Lyapunov stability
3. Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
4. Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
5. Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

**Lecture notes**
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

**Prerequisites / notice**
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

**151-0593-00L Embedded Control Systems**

**Abstract**
This course provides a comprehensive overview of embedded control systems. The concepts introduced are implemented and verified on a microprocessor-controlled haptic device.

**Objective**
Familiarize students with main architectural principles and concepts of embedded control systems.

**Content**
An embedded system is a microprocessor used as a component in another piece of technology, such as cell phones or automobiles. In this intensive two-week block course the students are presented the principles of embedded digital control systems using a haptic device as an example for a mechatronic system. A haptic interface allows for a human to interact with a computer through the sense of touch.

Subjects covered in lectures and practical lab exercises include:
- The application of C-programming on a microprocessor
- Digital I/O and serial communication
- Quadrature decoding for wheel position sensing
- Queued analog-to-digital conversion to interface with the analog world
- Pulse width modulation
- Timer interrupts to create sampling time intervals
- System dynamics and virtual worlds with haptic feedback
- Introduction to rapid prototyping

**Lecture notes**
Lecture notes, lab instructions, supplemental material

**Prerequisites / notice**
Prerequisite courses are Control Systems I and Informatics I.

This course is restricted to 33 students due to limited lab infrastructure. Interested students please contact Marianne Schmid Daners (E-Mail: marischm@ethz.ch)

After your reservation has been confirmed please register online at www.mystudies.ethz.ch.

Detailed information can be found on the course website
http://www.idsc.ethz.ch/education/lectures/embedded-control-systems.html

**151-0605-00L Nanosystems**

**Abstract**
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

Intermolecular forces, their macroscopic manifestations, and ways to control such interactions.

Self-assembly and directed assembly of 2D and 3D structures.

Special emphasis on the emerging field of molecular electronic devices.

**Objective**
Familiarize students with basic science and engineering principles governing the nano domain.
### Content

The course addresses basic science and engineering principles ruling the nano domain. We particularly work out the links between topics that are traditionally taught separately. Familiarity with basic concepts of quantum mechanics is expected.

Special emphasis is placed on the emerging field of molecular electronic devices, their working principles, applications, and how they may be assembled.

Topics are treated in 2 blocks:

(I) From Quantum to Continuum
From atoms to molecules to condensed matter: characteristic properties of simple nanosystems and how they evolve when moving towards complex ensembles.

(II) Interaction Forces on the Micro and Nano Scale
Intermolecular forces, their macroscopic manifestations, and ways to control such interactions. Self-assembly and directed assembly of 2D and 3D structures.

### Literature


### Prerequisites / notice

**Course format:**

Lectures and Mini-Review presentations: Thursday 10-13

**Homework:** Mini-Review
(compulsory continuous performance assessment)

Each student selects a paper (list distributed in class) and expands the topic into a Mini-Review that illuminates the particular field beyond the immediate results reported in the paper. Each Mini-Review will be presented both orally and as a written paper.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0621-00L</td>
<td>Microsystems I: Process Technology and Integration</td>
<td>W 6 credits 3V+3U</td>
<td>Haluska, C. Hierold</td>
</tr>
<tr>
<td>151-0642-00L</td>
<td>Seminar on Micro and Nanosystems</td>
<td>Z 0 credits 1S</td>
<td>Hierold</td>
</tr>
<tr>
<td>227-0145-00L</td>
<td>Solid State Electronics and Optics</td>
<td>W 6 credits 4G</td>
<td>Yazdani, V. Wood</td>
</tr>
<tr>
<td>227-0157-00L</td>
<td>Semiconductor Devices: Physical Bases and Simulation</td>
<td>W 4 credits 3G</td>
<td>Schenk, C. I. Roman</td>
</tr>
</tbody>
</table>
### Content

The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsinc properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions.

The exercises are focused on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

### Lecture notes

The script (in book style) can be downloaded from: [https://iis-students.ee.ethz.ch/lectures/](https://iis-students.ee.ethz.ch/lectures/)

### Literature

The script (in book style) is sufficient. Further reading will be recommended in the lecture.

### Prerequisites / notice


<table>
<thead>
<tr>
<th>227-0225-00L</th>
<th>Linear System Theory</th>
<th>W</th>
<th>6 credits</th>
<th>5G</th>
<th>J. Lygeros, A. Tsiamis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems. The exercises are focused on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>- Proof techniques and practices.</td>
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</tr>
<tr>
<td>Content</td>
<td>- Ordinary differential equations, existence and uniqueness of solutions.</td>
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<tr>
<td></td>
<td>- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.</td>
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<tr>
<td></td>
<td>- Controllability and observability, duality. Time invariant systems treated as a special case.</td>
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<tr>
<td></td>
<td>- Stability and stabilization, observers, state and output feedback, separation principle.</td>
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<tr>
<td>Lecture notes</td>
<td>Available on the course Moodle platform.</td>
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<tr>
<td>Notice</td>
<td>Sufficient mathematical maturity, in particular in linear algebra, analysis.</td>
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</table>

<table>
<thead>
<tr>
<th>227-0311-00L</th>
<th>Qubits, Electrons, Photons</th>
<th>W</th>
<th>6 credits</th>
<th>3V+2U</th>
<th>T. Zambelli</th>
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</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field, photons), and of electron transfer (from electrochemistry to photosynthesis). Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.</td>
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<tr>
<td>Objective</td>
<td>Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition! In this way, students will work out a robust quantum mechanics (theoretical!) basis which will help them in their advanced studies of the following masters: EET (batteries), Biomedical Engineering (NMR, bioelectronics), Quantum Engineering, Micro- and Nanosystems.</td>
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<tr>
<td>Content</td>
<td>- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets</td>
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<td></td>
<td>- Postulates of QM: Hilbert Spaces and Operators</td>
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<td></td>
<td>- Density Operator</td>
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<td></td>
<td>- Spin: Qubits, Bloch Equations, and NMR</td>
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<td></td>
<td>- Entanglement</td>
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<tr>
<td></td>
<td>- Symmetries and Corresponding Operators</td>
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<td></td>
<td>- Schrödinger's Wave Mechanics: Electrons in a Periodic Potential and Energy Bands</td>
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<td></td>
<td>- Harmonic Oscillator: Creation and Annihilation Operators</td>
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<td></td>
<td>- Identical Particles: Bosons and Fermions</td>
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<td></td>
<td>- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER</td>
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<tr>
<td></td>
<td>- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener</td>
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<tr>
<td>Lecture notes</td>
<td>No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!</td>
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</tr>
</tbody>
</table>
| Notice       | IMPORTANT: "qubits" from the point of view of NMR (and NOT from that of quantum computing)!

### Literature


Supplementary material will be uploaded in Moodle.

---

+ (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, "Lectures on the Mathematics of Quantum Mechanics I", 2015, Springer
+ (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.

### Prerequisites / notice

The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
The base for these lectures are lecture notes and two or three published scientific papers. From these papers, we will together develop the concepts and theories. The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Cm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

The base for these lectures is lecture notes and two or three published scientific papers. From these papers, we will together develop the technical content.

Details: https://people.ee.ethz.ch/~haschmid/asfwiki/

The graph methods are also supported with teaching videos: https://tube.switch.ch/channels/d206c96c?order=episodes, and a Python-based open-source tool to manipulate graphs is available on https://github.com/hanspi42/signalflowgrapher

Some material is protected by password; students from ETHZ who are interested can write to haschmid@ethz.ch to ask for the password even if they do not attend the lecture.

Prerequisites: Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.
Emerging Memory Technologies
A. Wallraff
6 credits

Basic aspects of surface science. Understanding of principles of most important experimental methods used in research concerned with

The course covers the status and prospects of post-silicon memory technologies, such as PCM, RRAM, STT-MRAM and FeRAM, and others. Students learn and compare these future memory technologies by means of interactive lectures, group projects, and laboratory sessions. The course employs constructive alignment and active learning teaching concepts.

Students will learn about main contenders for post-silicon storage-class memory. Decades of research made available several working principles for efficient memory devices, including phase-change of the structure (PCM), materials conversion (OxRAM), ion diffusion (CBRAM), magnetic properties (STT-MRAM and FeRAM), and others. Currently, these memory technologies emerge from research to industry, and many predict them at least niche applications for ever-growing hardware market. However, some of technologies (such as PCM) may even conquer the silicon-based flash memory eventually, providing better performance and unique features already now.

Students will compare emerging memory technologies with state-of-the-art SSD Flash and HDD memories and between each other’s. Selecting to study one technology in more details, students will evaluate its potential and acquire important presenting and critical thinking skills

The course is organized as a series of lectures, which are synchronized with student group projects, focusing on selected memory technologies. Students will spend 2h per week in the class and laboratory as well as 2-3 h per week working on group projects. The goal of the latter is to present selected memory technology in form of 3 presentations (20-25 min each), followed the example given by the lecturer.

Electromagnetic Precision Measurements and Opto-Mechanics
W. M. Frimmer
4 credits

Does not take place this semester.

The measurement process is at the heart of both science and engineering. Electromagnetic fields have proven to be particularly powerful probes. This course provides the basic knowledge necessary to understand current state-of-the-art optomechanical measurement systems operating at the precision limits set by the laws of quantum mechanics.

The goal of this course is to understand the fundamental limitations of measurement systems relying on electromagnetic fields.

The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement back-action, the inevitable result of the interaction of the probe with the system under investigation. The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics.

Nanooptics
A. Wallraff, J.-C. Besse, C. Hellings
6 credits

Nano-optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

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All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

Superconducting Circuits
A. Wallraff, J.-C. Besse, C. Hellings
6 credits

Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.

The main goal of this course is to equip students with the tools necessary to succeed in this emerging field of research. The course is positioned at the intersection between quantum physics and engineering.

All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

Programming Techniques for Scientific Simulations
R. Käppeli
5 credits

This course provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.

The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

Molecular Aspects of Catalysts and Surfaces
J. A. van Bokhoven, D. F. Ferri
6 credits

Basic elements of surface science important for materials and catalysis research. Physical and chemical methods important for research in surface science, material science and catalysis are considered and their application is demonstrated on practical examples.

Methods which are covered embrace: Gas adsorption and surface area analysis, IR-Spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, X-ray absorption, solid state NMR, Electron Microscopy and others.

Process Design and Development
G. Guillen Gosalbez
6 credits

The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.

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The course is focused on the design of Chemical Processes, with emphasis on the preliminary stages of the design approach, where process creation and quick selection among many alternatives are important. The main concepts behind more detailed process design and process simulation are also examined.
Content

- Process creation: heuristics vs. mathematical programming.
- Heuristics for reaction and separation operations, heat transfer and pressure change.
- Introduction to optimization in process engineering and the modeling software GAMS.
- Process economic evaluation: equipment sizing and costing, time value of money, cash flow calculations.
- Process environmental evaluation: Life Cycle Assessment (LCA).
- Process integration: sequencing of distillation columns using mixed-integer linear programming (MILP), and synthesis of heat exchanger networks using mixed-integer nonlinear programming (MINLP).
- Batch processes: scheduling, sizing, and inventories.
- Principles of molecular design using mixed-integer programming.

Lecture notes

Main books


Other references


Prerequisites / notice

Prerequisite: Basic knowledge on unit operations, mainly reaction engineering and distillation. It is recommended that the student takes the module "Process Simulation and Flowsheeting" before "Process Design and Development", but it is not mandatory.

701-1239-00L Aerosols I: Physical and Chemical Principles

Abstract

Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.

Objective

Physical and chemical principles:
- The students know the processes and physical laws of aerosol dynamics.
- The students understand the thermodynamics of phase equilibria and chemical equilibria.
- The students know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:
- The students know the most important chemical and physical measurement instruments.
- The students understand the underlying chemistry and physics.

Environmental impacts:
- The students know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- The students know the most important climate impacts of atmospheric aerosols.
- The students are aware of the health impacts of atmospheric aerosols.

Lecture notes

Material is distributed during the lecture

Literature


Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

752-3103-00L Food Rheology I

Abstract

Rheology is the science of flow and deformation of matter such as polymers, dispersions (emulsions, foams, suspensions), and colloidal systems. The fluid dynamical basis, measuring techniques (rheometry), and the flow properties of different fluids (Newtonian, non-Newtonian, viscoelastic) are introduced and discussed.
Objective
The course provides an introduction on the link between flow and structural properties of flowing material. Rheometrical techniques and appropriate measuring protocols for the characterization of complex fluids will be discussed. The concept of rheological constitutive equations and the application to different material classes are established.

Content
Lectures will be given on general introduction (4h), fluid dynamics (2h), complex flow behavior (4h), influence of temperature (2h), rheometers (4h), rheological tests (6h) and structure and rheology of complex fluids (4h).

Lecture notes
Notes will be handed out during the lectures.

Literature
Provided in the lecture notes.

► Multidisciplinary Courses
The students are free to choose individually Master's courses from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Course Catalogue of ETH Zurich

► Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT
see Science in Perspective: Language Courses ETH/UZH

► Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1007-00L</td>
<td>Semester Project Micro- and Nanosystems Only for Micro- and Nanosystems MSc.</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

The subject of the Semester Project and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

Abstract
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

► Industrial Internship

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship Access to the company list and request for recognition under <a href="http://www.mavt.ethz.ch/praxis">www.mavt.ethz.ch/praxis</a>.</td>
<td>O</td>
<td>8 credits</td>
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<td>external organisers</td>
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</table>

No registration required via myStudies.

Abstract
The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Objective
The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

► Master's Thesis

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-1006-00L</td>
<td>Master's Thesis Micro- and Nanosystems Students who fulfill the following criteria are allowed to begin with their Master's Thesis: a. successful completion of the bachelor program; b. fulfilling of any additional requirements necessary to gain admission to the master program; c. successful completion of the semester project; d. achievement of 32 ECTS in the category &quot;Core Courses&quot;. The Master's Thesis must be approved in advance by the tutor and is supervised by a professor of ETH Zurich.</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
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</table>

Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

Abstract
Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

Objective
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

Micro- and Nanosystems Master - Key for Type

| O  | Compulsory                  | E-  | Recommended, not eligible for credits |
| W+ | Eligible for credits and recommended | Z   | Courses outside the curriculum |
| W  | Eligible for credits        | Dr  | Suitable for doctorate |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1793 of 2416
## Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Exchange Students

Courses for Exchange Students

Prepare a study plan
In case the course catalogue of the upcoming semester is not available yet, please expect it to be like the year before.
You can study at ETH Zurich as an exchange student for 1 or 2 semesters, starting in the autumn or in the spring semester.
Exchange students may choose courses from different curricula and years, provided that at least two thirds of all courses are taken in the ETH Zurich department they are registered in. Please be sure to coordinate your schedule with your home university.

Exam sessions and End-of-semester examinations
Like all ETH Zurich students, exchange students are obliged to sit their exams during the official examination periods. Students are requested to be present at ETH Zurich during these periods. You are therefore expected to plan your studies, internships, jobs, and financial means accordingly.

Research Project

The courses below are only available for exchange students.

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<tr>
<th>Number</th>
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<td>ONLY for mobility students.</td>
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<td></td>
<td>Any other students (e.g.BSc, MSc, doctoral students) CANNOT enrol for this course unit.</td>
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<tr>
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<td>900-0010-00L</td>
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<td>21A</td>
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<tr>
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<td>900-0015-00L</td>
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<tr>
<td>Abstract</td>
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<td>900-0020-00L</td>
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<td>ONLY for mobility students.</td>
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<tr>
<td>Abstract</td>
<td>Independent project of 4 months, supervised by a professor</td>
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<td>900-0025-00L</td>
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<td>Any other students (e.g.BSc, MSc, doctoral students) CANNOT enrol for this course unit.</td>
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<td>Independent project of 5 months, supervised by a professor</td>
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<td>900-0030-00L</td>
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<tr>
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Additional Courses

by individual arrangement

Exchange Students - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
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<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<td>Suitable for doctorate</td>
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Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
## Core Courses

### Compulsory Core Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-1039-00L</td>
<td>Basics of Instrumentation, Measurement, and Analysis (University of Zurich)</td>
<td>O</td>
<td>4</td>
<td>9S</td>
<td>S.-C. Liu, T. Deibrück, R. Hahnloser, G. Indiveri, V. Mante, P. Pyk, D. Scaramuzza, W. von der Behrens</td>
</tr>
</tbody>
</table>

**Abstract**

Experimental data are always as good as the instrumentation and measurement, but never any better. This course provides the very basics of instrumentation relevant to neurophysiology and neuromorphic engineering, it consists of two parts: a common introductory part involving analog signals and signal acquisition (Part I), and a more specialized second part (Part II).

**Objective**

The goal of Part I is to provide a general introduction to the signal acquisition process. Students are familiarized with basic lab equipment such as oscilloscopes, function generators, and data acquisition devices. Different electrical signals are generated, visualized, filtered, digitized, and analyzed using Matlab (Mathworks Inc.) or Labview (National Instruments).

In Part II, the students are divided into small groups to work on individual measurement projects according to availability and interest. Students single-handedly solve a measurement task, making use of their basic knowledge acquired in the first part. Various signal sources will be provided.

**Prerequisites / notice**

For each part, students must hand in a written report and present a live demonstration of their measurement setup to the respective supervisor. The supervisor of Part I is the teaching assistant, and the supervisor of Part II is task specific. Admission to Part II is conditional on completion of Part I (report + live demonstration).

Reports must contain detailed descriptions of the measurement goal, the measurement procedure, and the measurement outcome. Either confidence or significance of measurements must be provided. Acquisition and analysis software must be documented.

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<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>O</td>
<td>2</td>
<td>1S</td>
<td>G. Indiveri</td>
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</table>

**Abstract**

The Neuroinformatics Journal club is a weekly meeting during which students present current research papers. The presentation last from 30 to 60 Minutes and is followed by a general discussion.

**Objective**

The Neuroinformatics Journal club aims to train students to present cutting-edge research clearly and efficiently. It leads students to learn about current topics in neurosciences and neuroinformatics, to search the relevant literature and to critically and scholarly appraise published papers. The students learn to present complex concepts and answer critical questions.

**Content**

Relevant current papers in neurosciences and neuroinformatics are covered.

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<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>227-1043-00L</td>
<td>Neuroinformatics - Colloquia (University of Zurich)</td>
<td>Z</td>
<td>0</td>
<td>1K</td>
<td>S.-C. Liu, R. Hahnloser, V. Mante</td>
</tr>
</tbody>
</table>

**Abstract**

The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.

**Objective**

The goal of these talks is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.

**Content**

The topics depend heavily on the invited speakers, and thus change from week to week. All topics concern neural computation and their implementation in biological or artificial systems.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<td>227-1045-00L</td>
<td>Readings in Neuroinformatics (University of Zurich)</td>
<td>O</td>
<td>3</td>
<td>1S</td>
<td>W. von der Behrens, R. Hahnloser, S.-C. Liu, V. Mante</td>
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</tbody>
</table>

**Abstract**

Thirteen major areas of research have been selected, which cover the key concepts that have led to our current ideas of how the nervous system is built and functions. We will read both original papers and explore the conceptual the links between them and discuss the ‘sociology’ of science, the pursuit of basic science questions over a century of research.”

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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1796 of 2416
It is commonplace that scientists rarely cite literature that is older than 10 years and when they do, they usually cite one paper that serves as the representative for a larger body of work that has long since been incorporated anonymously in textbooks. Even worse, many authors have not even read the papers they cite in their own publications. This course, ‘Foundations of Neuroscience’ is one antidote. Thirty major areas of research have been selected. They cover the key concepts that have led to our current ideas of how the nervous system is built and functions. Unusually, we will explore these areas of research by reading the original publications, instead of reading a digested summary from a textbook or review. By doing this, we will learn how the discoveries were made, what instrumentation was used, how the scientists interpreted their own findings, and how their work, often over many decades and linked together with related findings from many different scientists, generate the current views of mechanism and structure of the nervous system. We will read different original papers and explore the conceptual links between them and discuss the ‘sociology’ of science. We will also explore the personalities of the scientists and the context in which they made their seminal discoveries. Each week, course members will be given original papers to read for homework and they will write a short abstract for each paper. We will then meet weekly with the course leader and an assistant for an hour-or-so long interactive seminar. An intimate knowledge of the papers will be assumed so that the discussion does not center simply on an explication of the contents of the papers. Assessment will be in the form of a written exam where students will be given a paper and asked to write a short abstract of its contents.

It is commonplace that scientists rarely cite literature that is older than 10 years and when they do, they usually cite one paper that serves as the representative for a larger body of work that has long since been incorporated anonymously in textbooks. Even worse, many authors have not even read the papers they cite in their own publications. This course, ‘Foundations of Neuroscience’ is one antidote. Thirty major areas of research have been selected. They cover the key concepts that have led to our current ideas of how the nervous system is built and functions. Unusually, we will explore these areas of research by reading the original publications, instead of reading a digested summary from a textbook or review. By doing this, we will learn how the discoveries were made, what instrumentation was used, how the scientists interpreted their own findings, and how their work, often over many decades and linked together with related findings from many different scientists, generate the current views of mechanism and structure of the nervous system. We will read different original papers and explore the conceptual links between them and discuss the ‘sociology’ of science. We will also explore the personalities of the scientists and the context in which they made their seminal discoveries. Each week, course members will be given original papers to read for homework and they will write a short abstract for each paper. We will then meet weekly with the course leader and an assistant for an hour-or-so long interactive seminar. An intimate knowledge of the papers will be assumed so that the discussion does not center simply on an explication of the contents of the papers. Assessment will be in the form of a written exam where students will be given a paper and asked to write a short abstract of its contents.

Elective Core Courses

System Sciences

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>227-0421-00L</td>
<td>Deep Learning in Artificial and Biological Neuronal Networks</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Grewe</td>
</tr>
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</table>

**Objective**

The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

**Content**

Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al, 2015; Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much better performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training on the other hand seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

**Lecture notes**

The lecture slides will be provided as a PDF after each lecture.

**Prerequisites / notice**

This advanced level lecture requires some basic background in machine/deep learning. Thus, students are expected to have a basic mathematical foundation, including linear algebra, multivariate statistics, probability. The course is not to be meant as an extended tutorial of how to train deep networks in PyTorch or Tensorflow, although these tools used.

**Course content**

- Understanding computational neuroscience and how to design and train ANNs.
- Introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

**Introduction to Neuroinformatics**

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

**Objective**

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the fundamental concepts of physics, math, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enablers and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to solving solutions.
Content

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

227-1051-00L Systems Neuroscience (University of Zurich) W 6 credits 2V+1U+1A D. Kiper

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

Abstract This course focuses on basic aspects of central nervous system physiology, including perception, motor control and cognitive functions.

Objective To understand the basic concepts underlying perceptual, motor and cognitive functions.

Content Main emphasis sensory systems, with complements on motor and cognitive functions.

Lecture notes None


"Principles of Neural Science", Kandel, Schwartz, and Jessel

Prerequisites / notice none

Neural Computation and Theoretical Neurosciences

Number Title Type ECTS Hours Lecturers

227-1037-00L Introduction to Neuroinformatics W 6 credits 2V+1U+1A V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens

Abstract The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Content This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

227-0421-00L Deep Learning in Artificial and Biological Neuronal Networks W 4 credits 3G B. Grewe

Abstract Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas and concepts from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today's neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1798 of 2416
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world.

However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al., 2015, Silver et al., 2018), ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind of what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples; they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

### Neurotechnologies and Neuromorphic Engineering

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+1A</td>
<td>V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. van der Behrens</td>
</tr>
<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Delbrück, G. Indiveri, S.-C. Liu</td>
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**Abstract**

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

**Objective**

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchancements and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

**Content**

This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the brain can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

**Literature**

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

**Prerequisites / notice**

Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

**Prerequisites:** Background in basics of semiconductor physics helpful, but not required.
The course introduces bioelectricity and the sensing concepts that enable obtaining information about neurons and their networks. The sources of electrical fields and currents in the context of biological systems are discussed. The fundamental concepts and challenges of measuring bioelectronic signals and the basic concepts to record optogenetically modified organisms are introduced.

During this course the students will:
- learn the basic concepts in bioelectronics including the sources of bioelectric signals and the methods to measure them
- be able to solve typical problems in bioelectronics
- learn about the remaining challenges in this field

In vivo stimulation and recording
10. Functional electric stimulation
11. In vivo electrophysiology

Optical recording and control of neurons (optogenetics)
12. Measuring neurons optically, fundamentals of optical microscopy
13. Fluorescent probes and scanning microscopy, optogenetics, in vivo microscopy

14. Measuring biochemical signals

A detailed script is provided to each lecture including the exercises and their solutions.

Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.

Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte

eigenes Aufschrieb und K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002

K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, 5. Auflage 2002

Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and supercomputers. Optimization methods for scientific simulation codes are explained.

The objective of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

Abstract
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and supercomputers. Optimization methods for scientific simulation codes are explained.

Objective
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

Prerequisites / notice
Lecture notes and slides are available online and will be distributed if desired.

Literature
Literature recommendations and references are included in the lecture notes.

Content
Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are introduced to modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

Abstract
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content
This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in material science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Prerequisites / notice
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Literature
Thomas, Humphreys, Beanland: Electron Microscopy and Analysis, 3rd Ed., CRC Press, 2000
Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

Prerequisites / notice
For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

Content
Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to clinical radiation effects. Dealing with dose as a quantity, dose equivalent and effective dose, and their units. Comparison of ionizing and non-ionizing radiation. The concept of radiation dose: Measurement, conversion and dosimetry.

Objective
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement an abstract framework in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Abstract
An introduction to scientific computing. Basic mathematical concepts and computational tools used in scientific computing. Solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement an abstract framework in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

Objective
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

Abstract
This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are discussed, and modern research into its neural substrate, particularly in the visual domain, is explained. Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

Abstract
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and supercomputers. Optimization methods for scientific simulation codes are explained.

Objective
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.

Abstract
This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in material science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Objective
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content
This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in material science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Literature
Thomas, Humphreys, Beanland: Electron Microscopy and Analysis, 3rd Ed., CRC Press, 2000
Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

Prerequisites / notice
A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Literature
Thomas, Humphreys, Beanland: Electron Microscopy and Analysis, 3rd Ed., CRC Press, 2000
Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)
Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

▶ Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET

see Science in Perspective: Language Courses ETH/UZH

▶ Master’s Thesis and Semester Papers/Seminars

▶▶ Option 1: Long Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>227-1041-01L</td>
<td>NSC Master's Thesis (long) and Exam (University of Zurich)</td>
<td>W</td>
<td>45 credits</td>
<td>96D</td>
<td>M. F. Yanik</td>
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</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI503

Mind the enrolment deadlines at UZH:

Only students who fulfil the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract

The Master thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective

see above

▶▶ Option 2: Short Master’s Thesis and Semester Papers/Seminars

▶▶▶ Short Master Thesis

<table>
<thead>
<tr>
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<th>Lecturers</th>
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<tr>
<td>227-1041-02L</td>
<td>NSC Master's Thesis (short) and Exam (University of Zurich)</td>
<td>W</td>
<td>29 credits</td>
<td>62D</td>
<td>M. F. Yanik</td>
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</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI504

Mind the enrolment deadlines at UZH:

Only students who fulfil the following criteria are allowed to begin with their master thesis:
- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract

The Master thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective

see above

▶▶ Semester Papers/Seminars

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1036-01L</td>
<td>NSC Master Short Project I (University of Zurich)</td>
<td>W</td>
<td>8 credits</td>
<td>17A</td>
<td>M. F. Yanik</td>
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</tbody>
</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI505

Mind the enrolment deadlines at UZH:

Abstract

Usually a student selects the topic of a Master Short Project in consultation with his or her mentor.

Objective

see above

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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1036-02L</td>
<td>NSC Master Short Project II (University of Zurich)</td>
<td>W</td>
<td>8 credits</td>
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<td>M. F. Yanik</td>
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</table>

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: INI506

Mind the enrolment deadlines at UZH:

Abstract

see above

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1803 of 2416
Abstract
Usually a student selects the topic of a Master Short Project in consultation with his or her mentor.

Objective
see above

**Neural Systems and Computation Master - Key for Type**

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<td>Dr</td>
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**Key for Hours**

<table>
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<tr>
<td>V</td>
<td>lecture</td>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>S</td>
<td>seminar</td>
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<td>K</td>
<td>colloquium</td>
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<td>P</td>
<td>practical/laboratory course</td>
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<td>A</td>
<td>independent project</td>
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<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Core Courses

1. Semester (EPFL)

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>151-2011-00L</td>
<td>Physics of Nuclear Reactors (EPFL)</td>
<td>O</td>
<td>6</td>
<td>6G</td>
<td>external organisers</td>
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<td></td>
<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.</td>
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<tr>
<td>Abstract</td>
<td>In this course, one acquires an understanding of the basic neutronics interactions occurring in a nuclear fission reactor and, as such, the conditions for establishing and controlling a nuclear chain reaction.</td>
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<tr>
<td>Objective</td>
<td>By the end of the course, the student must be able to:</td>
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<tr>
<td></td>
<td>- Elaborate on neutron diffusion equation</td>
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<td></td>
<td>- Systematize nuclear reaction cross sections</td>
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<td></td>
<td>- Formulate approximations to solving the diffusion equation for simple systems</td>
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<td>Content:</td>
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<tr>
<td></td>
<td>- Brief review of nuclear physics</td>
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<td></td>
<td>- Historical: Constitution of the nucleus and discovery of the neutron - Nuclear reactions and radioactivity - Cross sections - Differences between fusion and fission.</td>
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<td></td>
<td>- Nuclear fission</td>
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<td></td>
<td>- Characteristics - Nuclear fuel - Introductory elements of neutronics.</td>
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<td></td>
<td>- Fissile and fertile materials - Breeding.</td>
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<td>- Neutron diffusion and slowing down</td>
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<td>- Monoenergetic neutrons - Angular and scalar flux</td>
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<td></td>
<td>- Diffusion theory as simplified case of transport theory - Neutron slowing down through elastic scattering.</td>
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<td></td>
<td>- Multiplying media (reactors)</td>
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<td>- Multiplication factors - Criticality condition in simple cases.</td>
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<td>- Reactor kinetics</td>
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<td>- Point reactor model: prompt and delayed transients - Practical applications.</td>
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<td></td>
<td>- Reactivity variations and control</td>
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<td>- Short, medium and long term reactivity changes ? Different means of control.</td>
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<td>Literature</td>
<td>Distributed documents, recommended book chapters</td>
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<td>Prerequisites / notice</td>
<td>Prerequisite for: Reactor Experiments</td>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>151-2013-00L</td>
<td>Radiation and Reactor Experiments (EPFL)</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>external organisers</td>
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<tr>
<td>Abstract</td>
<td>To gain hands-on experience in the conduction of nuclear radiation measurements, as also in the execution and analysis of reactor physics experiments using the CROCUS reactor.</td>
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<td>Objective</td>
<td>To gain hands-on experience in the conduction of nuclear radiation measurements, as also in the execution and analysis of reactor physics experiments using the CROCUS reactor.</td>
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<td>Content</td>
<td>- Radiation detector systems, alpha and beta particles</td>
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<td>- Radiation detector systems, gamma spectroscopy</td>
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<tr>
<td></td>
<td>- Introduction to neutron detectors (He-3, BF3)</td>
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<td></td>
<td>- Slowing-down area (Fermi age) of Pu-Be neutrons in H2O</td>
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<td></td>
<td>- Approach-to-critical experiments</td>
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<td>- Buckling measurements</td>
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<td></td>
<td>- Reactor power calibration</td>
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<td>- Control rod calibration</td>
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<td>Literature</td>
<td>Distributed documents, recommended book chapters</td>
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<td>Prerequisites / notice</td>
<td>Prerequisite for: Special Topics in Reactor Physics (2nd sem.)</td>
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<th>Lecturers</th>
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<tr>
<td>151-2015-00L</td>
<td>Reactor Technology (EPFL)</td>
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<td>4</td>
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<td>A. Manera, external organisers</td>
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<td>No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.</td>
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<tr>
<td>Abstract</td>
<td>Basic heat removal phenomena in a reactor core, limits for heat generation and technological consequences arising from fuel, cladding and coolant properties, main principles of reactor thermal design, as well as the general design of the nuclear power plant with its main and auxiliary systems are explained. The system technology of the most important thermal and fast reactor types is introduced.</td>
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<tr>
<td>Objective</td>
<td>By the end of the course, the student must be able to:</td>
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<tr>
<td></td>
<td>(1) Understand design principles of nuclear reactors,</td>
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<td>(2) Understand purpose and function of main reactor and power plant components and subsystems,</td>
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<td>(3) assess and evaluate the performance of reactor types,</td>
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<td>(4) systematize reactor system components,</td>
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<td>(5) formulate safety requirements for reactor systems</td>
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</tbody>
</table>

Autumn Semester 2022
Radiation Biology, Protection and Applications (EPFL) 151-2043-00L

**Content**
- Fuel rod, LWR fuel elements
- Temperature field in fuel rod
- Reactor core, design
- Flux and heat source distribution, cooling channel
- Single-phase convective heat transfer, axial temperature profiles
- Boiling crisis and DNB ratio
- Pressurized water reactors, design
- Primary circuit design
- Steam generator heat transfer, steam generator types
- Boiling water reactors
- Reactor design
- LWR power plant technology, main and auxiliary systems
- Breeding and transmutation, purpose of generation IV systems
- Properties of different coolants and technological consequences
- Introduction into gas-cooled reactors, heavy water moderated reactors, sodium and led cooled fast reactors, molten salt reactors, accelerator driven systems

**Objective**
By the end of the course, the student must be able to:

- Explain the basic physics principles that underpin radiotherapy, e.g. types of radiation, atomic structure, etc.
- Explain the interaction mechanisms of ionizing radiation at keV and MeV energies with matter.
- Explain the principles of radiation dosimetry.
- Explain the principles of therapeutic radiation physics including X-rays, electron beam physics, radioactive sources, use of unsealed sources and Brachytherapy.
- Describe how to use radiotherapy equipment both for tumour localisation, planning and treatment.
- Define quality assurance and quality control, in the context of radiotherapy and the legal requirements.
- Explain the principles and practice of radiation protection, dose limits, screening and protection mechanisms.
- Explain the use of radiation in industrial and research applications.

**Content**
Basics: radiation sources and interaction with matter, radioisotope production using reactors and accelerators, radiation protection and shielding.
Medical applications: diagnostic tools, radiopharmaceuticals, cancer treatment methodologies such as brachytherapy, neutron capture therapy and proton therapy.
Industrial applications: radiation gauges, radiochemistry, tracer techniques, radioisotope batteries, sterilization, etc.
Applications in research: dating by nuclear methods, applications in environmental and life sciences, etc.

Hydraulic Turbomachines (EPFL) 151-2021-00L

**Content**
- Turbomachine equations, mechanical power balance in a hydraulic machines, moment of momentum balance applied to the runner/impeller, generalized Euler equation.
- Hydraulic characteristic of a reaction turbine, a Pelton turbine and a pump, losses and efficiencies of a turbomachine, real hydraulic characteristics.
- Similarity laws, non dimensional coefficients, reduced scale model testing, scale effects.
- Cavitation, hydraulic machine setting, operating range, adaptation to the piping system, operating stability, start stop transient operation, runaway.
- Reaction turbine design: general procedure, general project layout, design of a Francis runner, design of the spiral casing and the distributor, draft tube role, CFD validation of the design, design fix, reduced scale model experimental validation.
- Pelton turbine design: general procedure, project layout, injector design, bucket design, mechanical problems.
- Centrifugal pump design: general architecture, energetic loss model in the diffuser and/or the volute, volute design, operating stability.

**Literature**

**Prerequisites / Notice**
No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

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Autumn Semester 2022

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Page 1806 of 2416
### Nuclear Fusion and Plasma Physics (EPFL)

**Abstract**
The goal of the course is to provide the physics and technology basis for controlled fusion research, from the main elements of plasma physics to the reactor concepts.

**Objective**
By the end of the course, the student must be able to:
- Design the main elements of a fusion reactor
- Identify the main physics challenges on the way to fusion
- Identify the main technological challenges of fusion

**Content**
1. Basics of thermonuclear fusion
2. The plasma state and its collective effects
3. Charged particle motion and collisional effects
4. Fluid description of a plasma
5. Plasma equilibrium and stability
6. Magnetic confinement: Tokamak and Stellarator
7. Waves in plasma
8. Wave-particle interactions
9. Heating and non inductive current drive by radio frequency waves
10. Heating and non inductive current drive by neutral particle beams
11. Material science and technology: Low and high Temperature superconductor - Properties of material under irradiation
12. Some nuclear aspects of a fusion reactor: Tritium production
13. Licensing a fusion reactor: safety, nuclear waste
14. Inertial confinement

**Literature**

**Prerequisites**
Required prior knowledge:
Basic knowledge of electricity and magnetism, and of simple concepts of fluids

### Introduction to Particle Accelerators (EPFL)

**Abstract**
The course presents basic physics ideas underlying the workings of modern accelerators. We will examine key features and limitations of these machines as used in accelerator driven sciences like high energy physics, materials and life sciences.

**Objective**
By the end of the course, the student must be able to:
- Design basic linear and non-linear charged particles optics
- Elaborate basic ideas of physics of accelerators
- Use a computer code for optics design
- Optimize accelerator design for a given application
- Estimate main beam parameters of a given accelerator

**Content**
Overview, history and fundamentals
Transverse particle dynamics (linear and nonlinear)
Longitudinal particle dynamics
Linear accelerators
Circular accelerators
Acceleration and RF-technology
Beam diagnostics
Accelerator magnets
Injection and extraction systems
Synchrotron radiation

**Literature**
Recommended during the course

**Prerequisites**
Prérequis: Notion de relativité restreinte et d'électrodynamique

### Introduction to Medical Radiation Physics (EPFL)

**Abstract**
This course covers the physical principles underlying medical imaging using ionizing radiation (radiography, fluoroscopy, CT, SPECT, PET).

**Objective**
The focus is not only on risk and dose to the patient and staff, but also on an objective description of the image quality.

**Content**
Image quality: Wagner's taxonomy, MTF, NPS, contrast, SNR, DQE, NEQ, CNR
Dose to the patient: External irradiation, Internal contamination, compartmental models
Physics of computer tomography (CT)
Risk and radiation: Rational risk and state of our knowledge, Psychological aspects, Ethics and communication
Physics of single-photon emission computed tomography (SPECT)
Physics of mammography
Receiver operating characteristics (ROC) and hypothesis testing: Link between medical diagnostic and statistical hypothesis testing, Sensitivity, specificity, prevalence, predictive values
Physics of radioscopy
Model observers in medical imaging: Human visual characteristics and their quantification, Bayesian cost and Ideal model observer, Anthropomorphic model observers, Detection experiments (rating, M-AFC, yes-no)
Physics of positron emission tomography (PET)
Physics of resonance magnetic imaging

### Energy Conversion and Renewable Energy (EPFL)

**Abstract**
No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

**Objective**
No objective information available.

**Content**
No content information available.

**Literature**
No literature information available.

**Prerequisites**
No prerequisites information available.
Radiation Detection (EPFL)

By the end of the course, the student must be able to:

- Explain the efficiency and the main emission sources of energy conversion processes
- Quantify the efficiency and the main emission sources of energy conversion processes
- Model energy conversion systems and industrial processes
- Draw the energy balances of an energy conversion system
- Elaborate energy conversion scenarios
- Describe the principles and limitations of the main energy conversion technologies
- Compare energy conversion systems

Content

- Overview of energy stakes
- Thermodynamic principles relevant for energy conversion systems, review of thermodynamic power cycles, heat pumps and refrigeration cycles, co-generation
- Carbon capture and sequestration
- Renewable energy vectors, their physical principles and essential equations: Solar (photovoltaics and thermal - collectors/concentrators), geothermal, biomass (a.o. gasification, biogases, liquid biofuels), hydro, wind
- Fuel cells and hydrogen as energy vector
- Storage of energy: Batteries, compressed air, pumped hydro, thermal storage
- Integrated urban systems

Lecture notes

Slides, videos and other documents are available on moodle (http://moodle.epfl.ch)

Prerequisites / notice

Required courses: Physics I and Physics II

Important concepts to start the course: Conservation principles (energy, mass, momentum)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Module</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-2051-00L</td>
<td>Radiation Detection (EPFL)</td>
<td>3</td>
<td>3G</td>
<td>external organisers</td>
</tr>
<tr>
<td>151-2053-00L</td>
<td>Experimental Methods in Physics (EPFL)</td>
<td>3</td>
<td>3G</td>
<td>external organisers</td>
</tr>
<tr>
<td>151-2055-00L</td>
<td>Image Processing I (EPFL)</td>
<td>3</td>
<td>3G</td>
<td>external organisers</td>
</tr>
</tbody>
</table>


No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

Abstract
The goal of the lecture is to present and apply techniques for the modelling and the thermo-economic optimisation of industrial process and energy systems. The lecture covers the problem statement, the solving methods for the simulation and the single and multi-objective optimisation problems.

Objective
By the end of the course, the student must be able to:
- Master the concepts of thermodynamic efficiency, E6
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E22
- Analyse the energy and exergy efficiency of industrial energy systems, E23
- Model, design and optimize energy conversion systems and industrial processes, E24
- Establish the flow diagram of an industrial process and calculate the corresponding energy and mass balance, E20
- Explain and apply the concepts of thermodynamic efficiency, E6
- Analyze the energy and exergy efficiency of industrial energy systems, E21
- Model, design and optimize energy conversion systems and industrial processes, E22

Content
- Concepts of Computer Aided Process System Engineering methods to tackle the problems of energy conversion systems modelling and optimisation. The students will acquire a methodology to state the problem, identify the solving procedure, solve the problem and analyse the results;
- Definition of the basic system modelling concepts : state variables, energy and mass balances, simulation parameters and equations, degree of freedom analysis, different types of specifications, inequalities, objective functions;
- Energy systems equipments models;
- System models : flowsheets, degrees of freedom, sequential or simultaneous solving approach, numerical methods and their implications;
- Measurement data reconciliation and parameter identification;
- Calculating systems performances : operating cost, efficiency, environmental impact, investments, thermo-economic and environomic performances;
- Stating and solving optimization problems : decision variables, objective functions and constraints, solving strategies, numerical methods and their implications;
- Realization of a case study.

151-2059-00L Neutron Scattering - Theory and Applications (EPFL) W 4 credits 4G 4G external organisers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

Abstract
Neutron scattering is one of the most powerful and versatile experimental methods to study the structure and dynamics of materials on the nanometer scale. This course covers basic theory, instrumentation and scientific applications.

Objective
The application of the neutron scattering spans from crystalline matter to bio-materials and engineering, including fields like magnetism and superconductivity. Similar to the vast possibilities with X-rays at synchrotron facilities, neutron scattering is a so-called large scale facility technique with neutron facilities among other at PSI in Switzerland, ILL in Grenoble and a new joint European Spallation Source under construction in Sweden.

Content
The course provides an introduction to the versatile experimental techniques of neutron scattering and covers the following aspects:

1) Theory of the neutron scattering cross section
2) Neutron sources and neutron instrumentation
3) Neutron imaging, neutron reflectivity and neutron small angle scattering
4) Neutron diffraction, crystal structures
5) Inelastic neutron scattering, phonons
6) Magnetic neutron scattering, magnetic structures
7) Inelastic magnetic neutron scattering, magnetic dynamics
8) Resonant Inelastic X-ray Scattering (RIXS) a complementary technique

The course contain lectures and exercise sessions. Exercise sessions will contain deriving relevant formulas, monte-carlo simulation of neutron scattering experiments, and discussion of representative scientific articles using neutron scattering.

The course is given every second year, alternating with a course about magnetism in solids.

151-2061-00L Nuclear Interaction : from Reactors to Stars (EPFL) W 4 credits 4G 4G external organisers

No enrolment to this course at ETH Zurich. Book the corresponding module directly at EPFL.

Abstract
This course will present an overview of the nuclear interactions for neutrons on nuclei below a few hundreds of MeV. The aspect of so-called “nuclear data” will be presented from the perspective of experiments, compilation, calculation, evaluation, processing and applications.

Objective
By the end of the course, the student must be able to: Use applications codes.

Content
- Nuclear data needs: It is important to understand if, and where, nuclear data are needed, why, which accuracy is required from the applications or industries. Such needs concerns a large range of applications: energy, medical, waste and astrophysics. Each of these fields requires different knowledge on nuclear interactions with, either with neutrons, or protons, or both.
- Theoretical background: Many of the needs are covered by experimental knowledge, but not all. Some reactions cannot be easily measured, or are simply out of range with current technologies (for instance for with short-lived isotopes). What can we do in this case? Part of the answer relies on theoretical understanding and the prediction power of current models (with their shortcoming). We will then explore (not in details) some of the important models, their range of applications, and what to do when nothing is known.
- Measurement facilities: The current knowledge of nuclear interactions, cross sections and uncertainties is based on measurements. In many instances, measurements are necessary due to the lack of prediction power for models. We will see the existing facilities, their advantages and drawback. We will also visit the installation worldwide, with a view on the future needs.
- Evaluation: Once quantities have been measured or calculated, they need to be presented to potential users. This step is called “evaluation”. The outcome of the process is “what the users will see”. It covers compiling measurements, combining them with theoretical predictions, formatting, and processing in forms that users need. We will go through these steps, and you will globally understand the importance of these steps.
- Applications: finally, we will see how these nuclear data are used. What are the applications, what are the needs, and how users can propose feedback to influence new measurements, or new calculations.
151-2063-00L Numerics for Fluids, Structures and Electromagnetics W 5 credits 4G external organisers

**Abstract**
The aim of the course is to give a theoretical and practical knowledge of the finite element method for saddle point problems, such as the ones of fluid dynamics, elasticity and electromagnetic problems.

**Objective**
By the end of the course, the student must be able to:
- Identify features of a PDE relevant for the selection and performance of a numerical algorithm.
- Assess / Evaluate numerical methods in light of the theoretical results.
- Implement numerical methods for saddle point problems
- Choose an appropriate method to solve a given differential problem
- Prove convergence of a discretisation scheme

---

151-2065-00L Particle-Based Methods (EPFL) W 4 credits 4G external organisers

**Abstract**
This course provides an introduction to particle-based methods for the numerical resolution of partial differential equations describing continuum phenomena or for the simulation of particulate flows. Details are given for the Material Point Method (MPM) and the Discrete Element Method (DEM).

**Objective**
By the end of the course, the student must be able to:
- Describe the difference between the Eulerian and Lagrangian approaches
- Identify and apply the different steps in a numerical simulation (e.g. geometry and mesh generation, computation, post-processing) and integrate all the essential basic concepts in a numerical flow simulation
- Describe different methods used to discretize differential equations, such as finite differences, finite elements, MPM, SPH, PFEM
- Perform a numerical simulation with appropriate software; understand the limits of each software in terms of its application domain and accuracy of the results obtained

---

151-2067-00L Plasma I (EPFL) W 6 credits 5G external organisers

**Abstract**
Following an introduction of the main plasma properties, the fundamental concepts of the fluid and kinetic theory of plasmas are introduced. Applications concerning laboratory, space, and astrophysical plasmas are discussed throughout the course.

**Objective**
By the end of the course, the student must be able to:
- Manipulate the fundamental elements of the plasma fluid and kinetic theory
- Inelastic collisions: ionization and recombination, degree of ionization
- Elastic collisions: Coulomb collisions
- Isotropisation and thermalisation
- Plasma resistivity and the runaway regime
- Transport in plasmas
- Random walk and diffusion
- Ambipolar and cross-field diffusion
- Energy and particle confinement
- Waves in cold magnetized plasma
- Dielectric tensor
- Resonances and cut-offs
- Parallel and perpendicular propagation
- Wave-particle interaction and kinetic description of waves in hot un-magnetized plasmas
- The Vlasov-Maxwell model
- Resonant wave-particle interaction and Landau damping
- Stability criteria and streaming instabilities
- Langmuir and ion-acoustic waves and instabilities
- Waves in hot magnetized plasmas
- Examples of nonlinear effects

---

151-2005-00L Elective Project Nuclear Engineering W 8 credits 17A Professors

**Abstract**
The elective project has the purpose to train the students in the solution of specific engineering problems related to nuclear technology. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.
Objective

The elective project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0150-00L</td>
<td>Advanced Topics in Nuclear Reactor Materials</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>M. A. Pouchon, P. J.-P. Späti, M. Streit</td>
</tr>
<tr>
<td>151-2037-00L</td>
<td>Nuclear Computations Lab</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>A. Pautz, H. Ferroukhi, further lecturers</td>
</tr>
<tr>
<td>151-2039-00L</td>
<td>Beyond-Design-Basis Safety</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>A. Manera, T. Lind, D. Paladino</td>
</tr>
<tr>
<td>151-2045-00L</td>
<td>Decommissioning of Nuclear Power Plants</td>
<td>O</td>
<td>4</td>
<td>3G</td>
<td>A. Manera, F. Leibundgut</td>
</tr>
<tr>
<td>151-205S-00L</td>
<td>Elective Project Nuclear Engineering</td>
<td>W</td>
<td>8</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract

The course deals with the important challenges for materials (structural and fuel) for current and advanced nuclear power plants. Experimental techniques and tools used for working with active materials are discussed in detail. Students will be well acquainted with analytical and modeling methodologies for damage assessment and residual life determination and with the behavior of high burnup fuel.

Objective

The behaviour of materials in nuclear reactors determines the reliability and safety of nuclear power plants (NPPs). Life extension and the understanding of fuel behavior under high burn-up conditions is of central importance for current-day NPPs. Advanced future systems (fission and fusion) need materials meeting additional challenges such as high temperatures and/or high doses. The course will highlight the above needs from different points of view. Experimental methods for the control and analysis of nuclear components and materials in operating NPPs will be presented. Advanced analytical and modeling tools will be introduced for material characterization and understanding of irradiation damage, creep, environment effects, etc. Insights acquired from recent experimental programs into high burnup fuel behavior under hypothetical accident conditions (RIA, LOCA) will be presented. Materials for advanced future nuclear plants will be discussed.

Literature


Prerequisites

Required prior knowledge: Special Topics in Reactor Physics, Nuclear Safety
The elective project has the purpose to train the students in the solution of specific engineering problems related to nuclear technology. Upon completion of the course students are able to:

- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications

Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship</td>
<td>O</td>
<td>8</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

Access to the company list and request for recognition under www.mavt.ethz.ch/praxis.

No registration required via myStudies.
Abstract
The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Objective
The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1020-00L</td>
<td>Semester Project Nuclear Engineering</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Only for Nuclear Engineering MSc.</td>
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<tr>
<td></td>
<td>The subject of the Semester Project and the choice of the supervisor (ETH or EPFL professor) are to be approved in advance by the tutor.</td>
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</table>

Abstract
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Objective
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's programme.

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1009-00L</td>
<td>Master's Thesis Nuclear Engineering</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Supervisors</td>
</tr>
<tr>
<td></td>
<td>Students who fulfill the following criteria are allowed to begin with their Master's Thesis: a. successful completion of the bachelor programme; b. fulfilling of any additional requirements necessary to gain admission to the master programme. c. successful completion of the semester project. d. completion of minimum 72 ECTS in the categories &quot;Core Courses&quot; and &quot;Electives&quot; in the Master studies and completion of 8 ECTS in the &quot;Semester Project&quot;</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>For the supervision of the Master's Thesis, the following professors can be chosen: H.-M. Prasser (ETHZ), A. Manera (ETHZ), M.Q. Tran (EPFL), A. Pautz (EPFL)</td>
<td></td>
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</tbody>
</table>

Abstract
Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by teh tutor and further elaborated with the student.

Objective
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

Nuclear Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Z</th>
<th>Courses outside the curriculum</th>
<th>W+</th>
<th>Eligible for credits and recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

Key for Hours

| V            | lecture                                   | P    | practical/laboratory course          |
| G            | lecture with exercise                     | A    | independent project                  |
| U            | exercise                                  | D    | diploma thesis                       |
| S            | seminar                                   | R    | revision course / private study      |
| K            | colloquium                                |      |                                      |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Pharmaceutical Sciences Master

Core Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0030-00L</td>
<td>Therapeutic Proteins</td>
<td>O</td>
<td>3 credits</td>
<td>3G</td>
<td>C. Halin Winter, D. Neri</td>
</tr>
</tbody>
</table>

Abstract
In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

Objective
Students know and understand:
- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins

Content
The course consists of two parts:

In a first part, students will complete their training of pharmaceutical immunology (Chapter 13 - 16 Immunobiology VIII textbook). This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.

The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

Lecture notes
Handouts to the lectures will be available for downloading under http://www.pharma.ethz.ch/scripts/index

Literature
- Janeway's Immunobiology, by Kenneth Murphy (9th Edition), Chapters 12-16
- Lecture Handouts
- Paper References provided in the Scripts
- EMEA Dossier for Humira

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0041-00L</td>
<td>Pharmacology and Toxicology III</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>U. Quitterer, M. Arand, Y. Yamauchi</td>
</tr>
</tbody>
</table>

Abstract
The course is divided into two parts. The first part provides a detailed understanding of drugs and the pharmacotherapy of infectious diseases and cancer. The second part gives an overview of the field of pharmacogenomics and toxicogenomics with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

Objective
The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases and cancer. The course also provides an overview of the field of pharmacogenomics and toxicogenomics, with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

Content
Topics include the pharmacology and pharmacotherapy of infectious diseases and cancer. In the field of pharmacogenomics and toxicogenomics, the course is focused on genetics, genome-wide association studies, examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development.

Lecture notes
A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.

Literature
Recommended reading:
The classic textbook in Pharmacology:
Goodman and Gilman’s The Pharmacological Basis of Therapeutics
Laurence Brunton, Bjorn Knollman, Randa Hilal-Dandan.
ISBN-10: 1259584739
or 14th edition (expected Oct. 2022)
or
Urban & Fischer (Elsevier, München)

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0050-00L</td>
<td>Pharmacoepidemiology and Drug Safety</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>A. Burden, S. Russmann</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.

Objective
Objectives:
- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for the quantitative evaluation of drug safety
- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

Content
- Historical landmarks of drug safety
- Pharmacoepidemiology and Drug Safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)
- Medication errors, clinical pharmacology / clinical pharmacy
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, Big Data
- Interactive discussion of many real-life examples for each topic

Lecture notes
This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through seminars, case studies in small groups.

Reading material and scripts will be provided for each week.
### Literature

**Recommended literature**

- Rothman: Introduction to Epidemiology
- Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
- Gigerenzer: Risk Savvy - How to Make Good Decisions

### Prerequisites / Notice

None

### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptable and Flexible</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Project Management</td>
<td>Leadership and Responsibility</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>Negotiation</td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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<tr>
<td>not assessed</td>
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<td>not assessed</td>
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<tr>
<td>not assessed</td>
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<td>not assessed</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

### Content

1. Introduction into industrial property (patents, trademarks, industrial designs);
2. Prosecution of patent applications (patentability);
3. Patent information (patent publications, databases, searches);
4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement);
5. Peculiarities in pharmaceutics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication);
6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions);
7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma-trademarks.

### Literature

**A script is provided in electronic form during the lecture.**

**Lecture notes**


### Abstract

Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Introduction into intellectual property; prosecution of patent applications; patent information; exploitation and enforcement of patents; peculiarities in pharmaceutics and medicine; social, political and ethical aspects; Trademarks.

### Objective

Basic knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.

### 511-0000-00L Drug Discovery and Development

*Only for MSc Pharmaceutical Sciences.*

**O 2 credits 1G+2S**


**Abstract**

This course provides an overview over the concepts and processes employed in today’s drug discovery and development. It has an introductory character but will also provide more detailed insights employing real life examples. The course combines lectures and interactive elements with active participation of the students.

**Objective**

Students

- Understand the drug discovery process and can explain major approaches and relevant technical terms (for details see lecture notes).
- Understand the content and timing of drug development process steps, development phases and decision criteria.
- Understand the concepts underlying drug product development through all the phases from preclinical and clinical development to regulatory submission, approval and market launch.
- Can differentiate between small molecule drug development and biological drug development.
- Understand the most important differences for drug development and approval between the EU and USA pharma markets with regard to legal and regulatory requirements.

**Content**

Course unit comprises weekly lectures covering the early phases of target and drug discovery (535-0901-01 S “From A to Z in Drug Discovery and Development I”) with group work in the area of Drug Development (511-0000-00 G). The latter course lasts 2 full days (Days 1 and 2) and comprises both lectures and group work: inter alia an introduction to the entire suite of drug product development processes in the pharmaceutical industry, covering preclinical research and development, clinical development, regulatory processes and market launch.

R&D support processes such as project management, quality management, pharmacovigilance and pharmacoepidemiology will be covered as well as organizational and governance aspects of the pharmaceutical industry. In addition, important success factors for a later career in the pharmaceutical industry will be briefly discussed at the end of day 2 of the course.

**Lecture notes**

Will be published on "mystudies." Further readings will be listed in the lecture notes.

**Literature**

- Rothman: Introduction to Epidemiology
- Strom, Kimmel, Hennessy: Textbook of Pharmacoepidemiology
- Gigerenzer: Risk Savvy - How to Make Good Decisions

**Prerequisites / Notice**

This course provides the essential basic knowledge required for the industry-specific modules of the spring semester.
The participants receive an introduction to basic formal aspects of scientific writing and the design of graphical elements. Lectures and discussions provide an overview of the fundamental concepts of scientific writing and the presentation of scientific data. The class enables the participants to prepare their own scientific texts and oral presentations, and critically assess the quality of the presentation of scientific data.

**Electives I**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>511-1001-00L</td>
<td><strong>Biopharmacy (Crash Course)</strong></td>
<td>E-</td>
<td>2</td>
<td>1S</td>
<td>S.-D. Krämer</td>
</tr>
</tbody>
</table>

**Abstract**

This introductory class provides an overview of the basic scientific writing techniques and a guideline to presenting scientific data, together with guided exercises and hands-on training. It is devised to accompany the research projects within the curriculum of the MSc in Pharmaceutical Sciences.

**Objective**

The class enables the participants to prepare their own scientific texts and oral presentations, and critically assess the quality of the presentation of scientific data.

**Content**

The participants receive an introduction to basic formal aspects of scientific writing and the design of graphical elements. Lectures and topical seminars alternate with practical tasks for the participants, which will be evaluated in a peer-to-peer setting. Performance feedback is provided by both the teachers and the peers.

**Prerequisites / notice**

Only for students of MSc Pharmacy and MSc Pharmaceutical Sciences.

**Biopharmacy (Crash Course)**

This course provides the basic concepts of biopharmacy (ADMET, absorption, distribution, metabolism, excretion, toxicity of drugs) and pharmacokinetics. After an introduction to the fundamental concepts, the participants will study independently and apply and consolidate their knowledge in tutorials. The course is reserved for students registered in the Master's programme in Pharmacy or in Pharmaceutical Sciences.

**Abstract**

The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences. Students work in small groups on a chosen topic, they write a mini-review and present their work on a one day symposium.

**Objective**

The main objectives of this course are:

- students develop their scientific reflection (Critical Thinking) and working skills by working independently on a relevant pharmaceutical topic
- students gain in-depth knowledge of the topic investigated
- students train their scientific writing and presentation skills
- students train their ability to plan a project and work in a team

**Content**

The Course Drug Seminar takes place during the first 7 weeks of the 1. Master semester. It is a compulsory course of the MSc Pharmacy curriculum and an elective course in the MSc PharmSciences.

The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences.

During the course, students work in small teams on a topic of their choice and elaborate a written mini-review and an oral presentation. Each team is tutored by a lecturer of the Institute of Pharmaceutical Sciences. The work is mainly based on literature search / review, but may also involve conducting interviews or site visits, if appropriate. The final presentations of all groups will take place in the framework of a dedicated Symposium held in the middle of the semester.

**Prerequisites / notice**

Only for students of MSc Pharmacy and MSc Pharmaceutical Sciences.

**Biopharmacy (Crash Course)**

This course provides the basic concepts of biopharmacy (ADMET, absorption, distribution, metabolism, excretion, toxicity of drugs) and pharmacokinetics. After an introduction to the fundamental concepts, the participants will study independently and apply and consolidate their knowledge in tutorials. The course is reserved for students registered in the Master's programme in Pharmacy or in Pharmaceutical Sciences.

**Abstract**

This course provides the basic concepts of biopharmacy (ADMET, absorption, distribution, metabolism, excretion, toxicity of drugs) and pharmacokinetics. After an introduction to the fundamental concepts, the participants will study independently and apply and consolidate their knowledge in tutorials. The course is reserved for students registered in the Master's programme in Pharmacy or in Pharmaceutical Sciences.

**Objective**

- Knowledge of the ADMET processes and the respective pharmacokinetic parameters.
- Interpretation of pharmacokinetic parameters.
- Analysis of drug plasma concentration-time curves.
- Prediction of pharmacokinetic parameters based on in vitro assays and physicochemical drug properties.
- Knowledge of the effects of physiological factors on the pharmacokinetic parameters and on drug plasma and tissue concentrations.
- Design of dosage regimens, based on pharmacokinetic parameters.
- Prediction of drug-drug interaction potentials based on in vitro assays and pharmacokinetic parameters.
- Introduction to compartment models, statistical models, physiological models.
- Pharmacokinetic profiling of drugs for therapy optimization and for the analysis of the interaction potential.
- Design of dosage regimens. In vitro assays to predict pharmacokinetic parameters.

**Content**

- Introduction to biopharmacy (ADMET) and pharmacokinetics.
- Definition of the most important pharmacokinetic parameters and their calculation from plasma concentration-time curves.
- Introduction to compartment models, statistical models, physiological models.
- Pharmacokinetic profiling of drugs for therapy optimization and for the analysis of the interaction potential.
- Design of dosage regimens. In vitro assays to predict pharmacokinetic parameters.

**Lecture notes**

Slides, see documents repository.

**Literature**


DOI: 10.1002/9783527645763


**Pharmaceutical Analytics and Pharmacoepia (Crash Course)**

This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation. After an introduction to the fundamental techniques and concepts, the participants will study independently, apply and consolidate their knowledge in tutorials.

**Prerequisites / notice**

Only for Pharmaceutical Sciences MSc.

**Abstract**

This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation. After an introduction to the fundamental techniques and concepts, the participants will study independently, apply and consolidate their knowledge in tutorials.

**Objective**

- students train their scientific writing and presentation skills
- students train their ability to plan a project and work in a team

**Content**

This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation. After an introduction to the fundamental techniques and concepts, the participants will study independently, apply and consolidate their knowledge in tutorials.

**Lecture notes**

Slides, see documents repository.

**Literature**


DOI: 10.1002/9783527645763

Objective
Students are able to:
summarize the structure of the Ph. Eur.
summarize the most important pharmacopeias and their communalities and differences
discuss the structure of a monograph
explain qualification of instruments and validation of methods
explain and compare most important analytical techniques for pharmaceutical industry

Content
Students gain knowledge in pharmaceutical analytics to fulfill regulatory requirements in pharmaceutical industry based on the pharmacopeia in force. Focus is set on method validation, equipment qualification, identification, purity testing and content determination of active pharmaceutical ingredients and excipients.

Lecture notes
Slides, see documents repository

Literature

511-1003-00L Gene Technology (Crash Course) E- 1 credit 1S J. Scheuermann
Obligatory course if assigned by the Admission committee.

Abstract
The course enables the student to understand and and apply the general concepts of gene technology, including recombinant DNA technology and its application in genomics, transcriptomics and proteomics. Protein cloning, expression and modifications and bimolecular interactions will be discussed. The concept of display technology and its applications in the field of drug discovery will be presented.

Objective
The students remember and understand:
1. The tools of recombinant DNA technology
2. Next generation sequencing approaches and their relevance for -omics projects
3. Protein cloning, expression, modification/labelling and oligomerization
4. Thermodynamic and kinetic affinity constants in bimolecular reactions
5. Basic structure of the antibody molecule
6. Concepts of antibody phage technology and antibody engineering
7. Construction of antibody-, peptide- or small molecule libraries and affinity-based selection methodologies

Content
I) Genomics:
- recombinant DNA technology
- methods to sequence genomes
- application to human biology
- Transcriptomics / Proteomics

II) Proteins:
- protein cloning and expression
- homo- and heterodimerization
- chemical modifications and radioactive labelling
- detection of bimolecular interactions
- affinity constant and experimental measurement
- kinetic association and dissociation constants

III) Display technology:
- the antibody molecule, CDRs, basics of antibody engineering
- antibody phage display and selection methodologies
- construction of antibody libraries
- other display technologies (peptide display, DNA-encoded chemical libraries)

Lecture notes
slides and script used for the course and literature for reading and discussions will be made available online.

Literature
dedicated chapters of:
dedicated articles will be announced

Prerequisites / notice
admission to MSc in Pharmaceutical Sciences

535-0423-00L Drug Delivery and Drug Targeting W 2 credits 1.5V J.-C. Leroux

Abstract
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective
The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature

Further references will be provided in the course.
Biotransformation of Drugs and Xenobiotics

Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.

Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.


In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs. The role of biodiversity (CBD, Rio 1992; Nagoya, 2010) and problems associated with drug discovery from natural products. Screening strategies for drug discovery (random screening versus screening based on cultural, ecological, ethnopharmacological, chemotaxonomic criteria). Traditional knowledge in relation to the fight against malaria and its implementation in research, product development and development cooperation. Introduction to and selected examples of herbal drugs and poisons, mode of action, and their ethnopharmacological importance. Critical analysis of bioprospecting as a drug discovery strategy.

Toxic reactions of metabolites. Factors which affect the biotransformation. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

From Ethnopharmacy to Molecular Pharmacognosy

Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Introduction into ethnopharmacy and related disciplines; definitions of terms, working methods, research projects, bioprospecting. Traditional medicinal plants of different cultures and their role in modern Western medicine (rational application of traditional uses). Historical data as sources for drug research. Today’s “fashion plants.” Empirical, traditional knowledge versus Evidence Based Medicine. The role of biodiversity (CBD, Rio 1992; Nagoya, 2010) and problems associated with drug discovery from natural products. Screening strategies for drug discovery (random screening versus screening based on cultural, ecological, ethnopharmacological, chemotaxonomic criteria). Traditional knowledge in relation to the fight against malaria and its implementation in research, product development and development cooperation. Introduction to and selected examples of herbal drugs and poisons, mode of action, and their ethnopharmacological importance. Critical analysis of bioprospecting as a drug discovery strategy.

Handouts will be provided.


Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.
The slides used for the lectures will be provided online.

### Analytical Competencies

Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent molecular mechanisms of drug actions and targets.

#### 1V: Adaptability and Flexibility

- Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:
  - major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
  - the major types of protein-linked glycans and the biosynthetic pathways for their formation.
  - how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

### Social Competencies

#### Communication

Lecture slides and literature for reading and discussions will be available online.

### Personal Competencies

- Adaptability and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

- Self-awareness and Self-reflection

- Self-direction and Self-management

### Content

- lecture plan:
  1. Glycans - information carriers in biology and pharmacotherapy
  2. Glucocerebrosidase and the biosynthesis of N-glycans
  3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
  4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
  5. Production and gCQA analysis of Glucocerebrosidase, monoclonal antibodies, glycoprotein hormone drugs - Glycoanalytics
  6. EPO "the same but different"

### Lecture notes

The slides used for the lectures will be provided online.

### Literature

- Recent publications as cited/proposed on the lecture slides.

### Prerequisites / notice

Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.

### Fostered competencies

#### Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

#### Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

#### Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

#### Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

### 535-0310-00L Glycobiology in Drug Development

**W**: 1 credit, **1V**: 2 credits, **V. I. Otto**

**Abstract**

Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.

**Objective**

Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:

- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
- the major types of protein-linked glycans and the biosynthetic pathways for their formation
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

**Content**

- lecture plan:
  1. Glycans - information carriers in biology and pharmacotherapy
  2. Glucocerebrosidase and the biosynthesis of N-glycans
  3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
  4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
  5. Production and gCQA analysis of Glucocerebrosidase, monoclonal antibodies, glycoprotein hormone drugs - Glycoanalytics
  6. EPO "the same but different"

**Lecture notes**

The slides used for the lectures will be provided online.

**Literature**

- Recent publications as cited/proposed on the lecture slides.

**Prerequisites / notice**

Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.

**Fostered competencies**

- Concepts and Theories
- Techniques and Technologies

**535-0300-00L Molecular Mechanisms of Drug Actions and Targets**

**W**: 2 credits, **V**: 1 credit, **J. Scheuermann**

**Abstract**

On average one drug per year is withdrawn from the market. Using selected examples of such drug failures, the course aims at analyzing and discussing the present explanations of drug actions as well as the design and predictive power of animal models and clinical trials. In addition, the ethical, societal, and economical expectations in new drugs shall be reflected and discussed.

**Objective**

To develop a critical understanding of the relevance and limitations of the current approaches to explaining and anticipating drug effects. To critically appraise the ethical, societal, economical and political expectations in the development of new drugs.

**Content**

In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed economic and political expectations in new drugs shall be reflected.

**Lecture notes**

Lecture slides and literature for reading and discussions will be available online.

**Prerequisites / notice**

Requirements: basic knowledge in Medicinal Chemistry and Pharmacology. Ability to read and understand scientific publications written in English.

**535-0021-00L Vitamins in Health and Disease**

**W**: 1 credit, **V**: 2 credits, **C. Müller**

**Abstract**

Vitamins are essential organic compounds that cannot be synthesized by an organism and hence, thy have to be acquired from the diet. This lecture will give an overview of the application of vitamins in health and disease.

**Objective**

The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.
Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested. A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period.

The lecture 'Vitamins in Health and Disease' will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

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### Evidence Based Phytotherapy

<table>
<thead>
<tr>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed</td>
<td></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Students should learn the importance of rational (= evidence-based) pharmacotherapy with herbal extracts. They should know the most important aspects of herbal medicinal products: o How are interesting development candidates identified. What are the strategies? o What are the regulatory requirements (Traditional use, well-established use, new herbal entities)? o Efficacy determination (animal/human studies, biomarkers) o Pharmacokinetics o Safety (toxicity, adverse effects, interactions) o Pharmaceutical quality o Origin of the plant raw material (wild collections, cultivation) o Ensuring consistent quality o Which extraction methods?</td>
<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>The following important plants and products will be presented and critically discussed as examples (see program below) 1) 21.09.2 Introduction: Quality of medicinal plant, finished products, monographs (Commission E, ESCOP, HMPC), differences in terms of registration status and requirements: traditional use, well established use and new herbal entities; extracts, quality medicinal drugs. 2) 28.9.2022: Phases of clinical development, basic concepts of evidence-based medicine. Hypericum perforatum 3) 05.10.2022 - no face-to-face lecture (lecture will be pre-recorded) Silybum marianum; Pelargonium spp. 4) 12.10.2022 Phytotherapy for functional intestinal disorders; Harpagophytum spp. 5) 19.10.2022: Lavandula oleum; Echinacea spp. 6) 26.10.2022: Cimicifuga racemosa; Cannabis sativa 7) 02.11.2022: Exam (Multiple Choice). The selection of plants may be subject to change.</td>
<td></td>
</tr>
</tbody>
</table>

**Prerequisites / notice** Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

**Lecture notes** Hand-outs will be distributed during the lecture (partly in English, partly in German).

**Literature** Book recommendation: reference books:

- Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-8304-6071-8

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### Clinical Chemistry II

<table>
<thead>
<tr>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
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<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.</td>
<td></td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interpretate selected tests.</td>
<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.</td>
<td></td>
</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Documentation will be available before the lectures electronically.</td>
<td></td>
</tr>
</tbody>
</table>

**Prerequisites / notice** Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

**Lecture notes** Hand-outs will be distributed during the lecture (partly in English, partly in German).
The topics include molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

Objective

The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

Content

The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).

Lecture notes

Script will be available.

Literature

Recommended textbooks:

535-0024-00L Methods in Drug Design

Does not take place this semester.

Abstract

The lecture is organized as a two-week block during the practical course "Computer-Assisted Drug Design" (535-0023-00L), totalling 10 two-hour lectures. It provides an introduction to advanced drug design techniques and approaches emphasizing computer-assisted molecular design.

Objective

Participants will learn about computational algorithms and advanced experimental approaches to drug discovery and design, including selected actual topics and practical applications. The contents of the lecture will allow for a deeper understanding of modern computer-assisted drug design methods and how they are linked to experimental applications. The main focus is on computational medicinal chemistry, so that participants will be able to use relevant computer-based methods in own research projects.

Literature


Prerequisites / notice

Additional selected literature will be provided during the lecture.

535-0023-00L Computer-Assisted Drug Design (Practical Course)

Does not take place this semester. Limited number of participants.

Abstract

The practical course is open for master and graduate students to get an introduction into hands-on computer-assisted drug design. The class includes an introduction to computer-based screening of a virtual compound library, subsequent synthesis of candidate ligands, and biochemically testing for activity on pharmacologically important drug targets.

Objective

Participants become familiar with state-of-the-art methodologies in a real-life computer-aided medicinal chemistry project. Participants work as small teams, perform literature research and discuss recent research findings. A seminar talk is to be given presenting the molecular design strategy chosen and the results obtained during the course.

Content

The course offers the possibility for people with and without computational and or laboratory background to get an introduction into computer-assisted drug design, as well as practical training in a modern chemical laboratory. Using various software suites, the participants will computationally create and screen a virtual compound library for potential active small molecules. The process will involve an introduction to screening a virtual compound library, synthesizing candidate inhibitors, and biophysical testing against a pharmacologically important drug target.

Lecture notes

Detailed information will be handed out during the course.

Literature

Textbook:

Prerequisites / notice

The class is organized as a two-week block course. The number of participants is limited.

Kick-off meeting and confirmation of registration (Vorbesprechung und Platzvergabe): During the last lecture of the class "Computer-Assisted Drug Design" (535-0022-00) participants get acquainted with scientific working methods and deepen their knowledge in a particular research area.

Research Project

Number Title Type ECTS Hours Lecturers
511-0003-00L Practical Methods in Pharmaceutical Sciences O 8 credits 17A Lecturers

Objective

Students get acquainted with scientific working methods and deepen their knowledge in a particular research area.

Electives II

Number Title Type ECTS Hours Lecturers
511-0004-00L Research Project W 15 credits 39A Lecturers

Objective

Students get acquainted with scientific working methods and deepen their knowledge in a particular research area.

Prerequisites / notice

Prerequisite: Practical Methods in Pharmaceutical Sciences passed

511-0005-00L Internship W 10 credits 31A Lecturers
The internship takes place outside universities, the main locations being: pharmaceutical industry, consultancy, health and regulatory authorities and hospitals. Students experience the professional handling of questions in the field of pharmaceutical sciences through their own practical activities and be able to implement the knowledge gained, by:
- analysing problems in their complexity and developing solutions in a conceptual way,
- experiencing the aspects of an everyday working environment,
- acquiring key skills,
- establishing contacts for prospective careers.

Work experience outside of university, duration of at least 12 weeks.

An internship agreement is set up between the student, the company and a member of the teaching staff of the Institute of Pharmaceutical Sciences.

At the end of the internship, the student draws up a formal report.

**Course Units for Additional Admission Requirements**

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
| 535-0421-AAL | Galenical Pharmacy I+II  
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. | E-   | 4 credits | 7R    | J.-C. Leroux |

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Knowledge of pharmaceutical excipients, materials, containers, liquid, solid and semi-solid dosage forms, their production, function, quality and application. Knowledge of the most important pharmaceutical excipients, materials, containers, liquid, solid and semi-solid dosage forms, their production, function, quality and application. Comprehension of the molecular interactions in solid state, solution and colloidal systems.


Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

535-0521-AAL  Pharmacology and Toxicology I+II  E-  5 credits  7R  U. Quitterer

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course is a condition for admission to the Pharmaceutical Sciences Master. By self-directed learning, students acquire knowledge about basic principles in pharmacology and toxicology, mechanisms of drug action and clinical uses of important classes of drugs.

Objective
After the successful completion of this course, students have gained knowledge about basic principles in pharmacology and toxicology, mechanisms of drug action and clinical uses of important classes of drugs.

Content
Contents of this course are defined by the textbook "Basic and Clinical Pharmacology" by Bertram Katzung.
The following sections are exam-relevant.

Section-I Basic Principles, No. 2,3,4.
Section-II, Autonomic Drugs, No. 6,7,8,9,10.
Section-III Cardiovascular-Renal Drugs, No. 11,12,13,15.
Section-IV Drugs with Important Actions on Smooth Muscle, No. 16,20.
Section-V Drugs that Act in the Central Nervous System, No. 21,22,24,26,27,28,29,30,31.
Section-VI Drugs Used to Treat Diseases of the Blood, Inflammation and Gout, No. 34,35,36.
Section-VII Endocrine Drugs, No. 39,41.

Lecture notes
Course contents are defined by the textbook "Basic and Clinical Pharmacology" by Bertram Katzung and Anthony Trevor. Exam-relevant sections of this book are listed above in the contents section.

Literature
Basic and Clinical Pharmacology
Bertram Katzung, Todd W. Vanderah
15th edition (Dec. 2020)
McGraw-Hill Education
ISBN-10: 126045231X

376-0172-AAL  Anatomy I+II  E-  5 credits  11R  D. P. Wolfer

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction into the histology and anatomy of the human body, including the musculoskeletal, cardio-respiratory, digestive, endocrine, urinary, reproductive systems, as well as the nervous system and sensory organs.

Objective
Students acquire basic knowledge of the micro- and macro structure of the organ systems in the human body. They understand basic concepts of the relationship between structure and function, and - based on examples - of the relationship between structural changes and disease.

376-0173-AAL  Physiology I+II  E-  5 credits  11R  C. Spengler

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Principles of human physiology and clinical pathophysiology.

Objective
Understand the basic principles of human physiology and mechanisms of related clinical pathophysiology.

406-0603-AAL  Stochastics (Probability and Statistics)  E-  4 credits  9R  M. Kalisch

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".
Pharmaceutical Sciences Bachelor

Bachelor Studies (Programme Regulations 2020)

First Year Compulsory Subjects

First Year Examinations

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-1001-01L</td>
<td>General Chemistry (for Biol./Pharm.Sc.)</td>
<td>O</td>
<td>4 credits</td>
<td>4V+2U</td>
<td>J. Cvengros</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>The lecture deals with a number of basic chemistry concepts. These include (amongst others) chemical reactions, energy transfer during chemical reactions, properties of ionic and covalent bonds, Lewis structures, properties of solutions, kinetics, thermodynamics, acid-base equilibria, electrochemistry and properties of metal complexes.</td>
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<td></td>
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<td></td>
<td>The course is designed to provide an understanding of the basic principles and concepts of general and inorganic chemistry.</td>
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<tr>
<td></td>
<td>Catherine Housecroft, Edwin Constable, CHEMISTRY: AN INTRODUCTION TO ORGANIC, INORGANIC AND PHYSICAL CHEMISTRY, 3. Auflage, Prentice Hall, 2005.(englisch)</td>
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<td>Techniques and Technologies</td>
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<td>Decision-making</td>
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<td></td>
<td>Project Management</td>
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<td>529-1011-00L</td>
<td>Organic Chemistry I (for Biol./Pharm.Sc./HST)</td>
<td>O</td>
<td>4 credits</td>
<td>4G</td>
<td>C. Thilgen</td>
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<td>Abstract</td>
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<tr>
<td></td>
<td>Fundamentals of Organic Chemistry; molecular structure. Bonding and functional groups; nomenclature; resonance and aromaticity; stereochemistry; conformation; bond strength; organic acids and bases; basic reaction thermodynamics and kinetics; reactive intermediates: carbanions, carbenium ions and radicals.</td>
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<td>Understanding the basic concepts and definitions of organic chemistry. Knowledge of the functional groups and classes of compounds that are important in biological systems. Foundations for the understanding of the relationship between structure and reactivity.</td>
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<td>Content</td>
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<td>Lecture notes</td>
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<td></td>
<td>Printed lecture notes are available. Exercises, answer keys and other handouts can be downloaded from the Moodle course &quot;Organic Chemistry I&quot; of the current semester (<a href="https://moodle-app2.let.ethz.ch">https://moodle-app2.let.ethz.ch</a>).</td>
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<td>Prerequisites / notice</td>
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<td>The course consists of lectures (36 hours) and problem-solving lessons (20 hours, groups of ca. 25 people). In addition, online exercises are available in the e-learning environment Moodle (Course OC I).</td>
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<td>Sensitivity to Diversity</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</table>

| 551-0125-00L | Fundamentals of Biology I: From Molecules to the   | O    | 4 credits | 5G | J. Vorholt-Zambelli, N. Ban, |
|             |                                                   |      |           |   |                     |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1825 of 2416
Biochemistry of Cells

Abstract
The lecture provides an introduction to the basics of biochemistry and molecular biology as well as evolutionary principles. The focus is on bacteria and archaea under consideration of universal concepts.

Objective
Introduction to biochemistry, molecular biology and evolutionary principles

Content
The lecture introduces biology as an interdisciplinary science. Links to physics and chemistry will manifest as biological processes that operate within the laws of thermodynamics and are rooted in elements, molecules and chemical reactions. The transition from geochemistry to biochemistry is discussed and considered in relation to the origin of life. Evolutionary principles are introduced and resulting processes are used as a guiding principle. Unifying concepts in biology are presented, including the structure and function of cellular macromolecules and the ways in which hereditary information is encoded, decoded and replicated. Central principles of universal energy conversion are looked at, starting from redox processes and focusing on bacteria and archaea. Finally, biological processes are put into an ecosystems perspective.

The lecture is divided into different sections:
1. Geochemical perspectives on Earth and introduction to evolution
2. Building blocks of life
3. Macromolecules: Proteins
4. Membranes and transport across the plasma membrane
5. Universal mechanisms of inheritance, transcription and translation
6. Reaction Kinetics, binding equilibria and enzymatic catalysis
7. Essentials of Catabolism
8. Essentials of Anabolism
9. Metabolism and biogeochemical cycling of elements

Lecture notes
The newly conceived lecture is supported by scripts.

Literature

First Year Examination Block 2

<table>
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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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Abstract
First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences, which are focused on within the first two years as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

Objective
First identification with Pharmaceutical Sciences; motivation for profiling in the Natural Sciences as a preparation for the specialized studies; sensitization for the duties and the responsibilities of a person with a federal diploma in Pharmacy; information about job opportunities.

Content
Introduction to Pharmaceutical Sciences by selected milestones of research and development. Overview on research activities at the Institute of Pharmaceutical Sciences that is focussed on drug delivery and development (from concepts to prototypes). Sensitization for communication skills and information management. Demonstration of job opportunities in community pharmacies, in the hospital, in industry, and in the public sector by experts in the different fields.

Lecture notes
Handouts for individual lectures.

Prerequisites / notice
Interactive teaching

<table>
<thead>
<tr>
<th>Number</th>
<th>Mathematics I</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>401-0291-00L</td>
<td>Mathematics I</td>
<td>O</td>
<td>6 credits</td>
<td>4V+2U</td>
<td>E. W. Farkas</td>
</tr>
</tbody>
</table>

Abstract
Mathematics I is an introduction to one- and multidimensional calculus and linear algebra emphasizing on applications.

Objective
Students understand mathematics as a language for modeling and as a tool for solving practical problems in natural sciences. Students can analyze models, describe solutions qualitatively or calculate them explicitly if need be. They can solve examples as well as their practical applications manually and using computer algebra systems.
### Eindimensionale diskrete Entwicklungen ###
- linear, exponentiell, begrenzt, logistisch
- Fixpunkte, diskrete Veränderungsrate
- Folgen und Grenzwerte

### Funktionen in einer Variablen ###
- Reproduktion, Fixpunkte
- Periodizität
- Stetigkeit

### Differentialrechnung (I) ###
- Veränderungsrate/-geschwindigkeit
- Differentialquotient und Ableitungsfunction
- Anwendungen der Ableitungsfunction

### Integralrechnung (I) ###
- Stammfunktionen
- Integrationstechniken

### Gewöhnliche Differentialgleichungen (I) ###
- Qualitative Beschreibung an Beispielen: Beschränkt, Logistisch, Gompertz
- Stationäre Lösungen
- Lineare DGL 1. Ordnung
- Trennung der Variablen

### Lineare Algebra ###
- Erste Arithmetische Aspekte
- Matrizenrechnung
- Eigenwerte / -vektoren
- Quadratische LGS und Determinante

---

Lecture notes

In Ergänzung zu den Vorlesungskapiteln der Lehrveranstaltungen fassen wir wichtige Sachverhalte, Formeln und weitere Ausführungen jeweils in einem Vademecum zusammen.

Dabei gilt:

* Die Skripte ersetzen nicht die Vorlesung und/oder die Übungen!
* Ohne den Besuch der Lehrveranstaltungen verlieren die Ausführungen ihren Mehrwert.
* Details entwickeln wir in den Vorlesungen und den Übungen, um die hier bestehenden Lücken zu schliessen.
* Prüfungsrelevant ist, was wir in der Vorlesung und in den Übungen behandeln.

Literature

Siehe auch Lernmaterial > Literatur

**L. Papula**
Mathematik für Ingenieure und Naturwissenschaftler, 2 Bände; Springer Verlag Vieweg.
Via ETHZ-Bibliothek:

**Th. Wihler**
Mathematik für Naturwissenschaften, 2 Bände: Einführung in die Analysis, Einführung in die Lineare Algebra; Haupt-Verlag Bern, UTB.

**H. H. Storrer**
Einführung in die mathematische Behandlung der Naturwissenschaften I; Birkhäuser.
Via ETHZ-Bibliothek:
https://link.springer.com/book/10.1007/978-3-0348-8598-0

**Ch. Blatter**
Lineare Algebra; VDF auch als [pdf](<https://people.math.ethz.ch/~blatter/linalg.pdf>)

---

Prerequisites / notice

# Übungen und Prüfungen #
- Die Übungsaufgaben (inkl. Multiple-Choice) sind ein wichtiger Bestandteil der Lehrveranstaltung.
- Es wird erwartet, dass Sie mindestens 75 % der wöchentlichen Serien bearbeiten und zur Korrektur einreichen.
- Der Prüfungsstoff ist eine Auswahl von Themen aus Vorlesung und Übungen. Für eine erfolgreiche Prüfung ist die konzentrierte Bearbeitung der Aufgaben unerlässlich.

---

402-0073-00L  Physics I  3 credits  2V+2U  T. M. Ihn

Abstract

Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics and elements of quantum mechanics.

Objective

Students know and understand the basic ideas of the scientific description of nature. They understand the fundamental concepts and laws of mechanics and they are able to apply them in practical problems. They know the concepts of quantization and quantum numbers.

Content

1. Description of Motion
2. The laws of Newton
3. Work and energy
4. Collision problems
5. Wave properties of particles
6. The atomic structure of matter

Lecture notes

T. Ihn: Physics for Students in Biology and Pharmaceutical Sciences (unpublished lecture notes)
The lecture contains elements of:

- Feynman, Leighton, Sands, "The Feynman Lectures on Physics", Volume I (http://www.feynmanlectures.caltech.edu/)

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Critical Thinking</td>
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</tbody>
</table>

Subject-specific Competencies

- Assessment of concepts and theories

Method-specific Competencies

- Assessment of analytical competencies
- Assessment of problem-solving

Social Competencies

- Assessment of cooperation and teamwork

Personal Competencies

- Assessment of critical thinking
- Assessment of self-awareness and self-reflection
- Assessment of self-direction and self-management

Additional First Year Courses

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<tr>
<th>Number</th>
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<td>535-0667-00L</td>
<td>Communication and Social Competences</td>
<td>O</td>
<td>1 credit</td>
<td>1V</td>
<td>to be announced</td>
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</table>

Abstract

Introduction in basic skills for increasing the effectiveness and efficiency of students daily work.

Objective

1) know tools to "study in a paperless way"; have tried out these tools and made their own conscious choice of useful tools.
2) know tools to work efficiently and goal-oriented in teams.
3) can approach problems methodically correct; know important problem-solving techniques.
4) are able to handle scientific texts and sources correctly; know how to write scientific papers.
5) know how to avoid social problems in working teams and how to solve them when they exist.

Content

Corresponding learning goals

Lecture notes

Handouts and working papers.

Literature

- Braun Walter, Die (Psycho-) Logik des Entscheidens, Fallstricke, Strategien und Techniken im Umgang mit schwierigen Situationen, Huber, 2010
- Stadelwieser Jürg, Kommunikation als Schlüssel zum Erfolg, Tobler, 2000 (vergriffen/Bibliothek).

Prerequisites / notice

None

Laboratory Course General Chemistry (for Biology and Pharmacy)

<table>
<thead>
<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tr>
<td>535-1001-00L</td>
<td>Laboratory Course General Chemistry (for Biology and Pharmacy)</td>
<td>O</td>
<td>6 credits</td>
<td>8P</td>
<td>S. Gruber, J. Hall</td>
</tr>
</tbody>
</table>

Abstract

Introduction to the practical work in a chemistry laboratory. The most important manipulations and techniques are treated, as well as the most fundamental chemical reaction types.

Objective

- Knowledge of the basic chemical laboratory methods
- Basic knowledge of the scientific approach in experimenting
- Observation and interpretation of chemical processes
- Keeping of a reliable laboratory journal

Content

- Simple chemical working techniques/methods
- Separation techniques
- Physical measurements: mass, volume, pH
- Ionic solids (salts)
- Acid/base chemistry, buffers
- Redox reactions
- Metal complexes
- Titrations methods and quantitative spectrometry
- Introduction to qualitative analysis

Lecture notes

Course manual in German (is handed out to the students at the beginning of the lessons)

Language: German, English upon request

Literature


is a suitable textbook.

Prerequisites / notice

This practical course causes costs for materials and chemicals. The costs are charged to the students at the end of semester.

Safety concept:
https://chab.ethz.ch/studium/bachelor1.html

Second Year Courses

Core Courses

<table>
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<tr>
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<td>252-0852-00L</td>
<td>Foundations of Computer Science</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>L. E. Fässler, M. Dahinden</td>
</tr>
</tbody>
</table>

Abstract

Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects.

The following topics are covered: modeling and simulations, introduction to programming, introduction matrices, managing data with lists and tables and with relational databases, universal methods for algorithm design.
Objective: The students learn to:
- understand the role of computer science in science,
- to control computer and automate processes of problem solving by programming,
- choose and apply appropriate tools from computer science,
- process and analyze real-world data from their subject of study,
- handle the complexity of real-world data.

Content:
1. The role of computer science in science
2. Introduction to Programming with Python
3. Modeling and simulations
4. Data management with lists and tables
5. Data management with a relational database
6. Introduction to Matrices

Prerequisites / notice: This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available.

401-0643-13L Statistics II

Abstract: Verifikation von Statistikmethoden. Nach dem detaillierten Fundament aus Statistik I liegt nun der Fokus auf konzeptueller Breite und konkreter Problemlösungsfähigkeit mit der Statistiksoftware R.


551-0127-00L Fundamentals of Biology III: Multicellularity

Abstract: The lecture conveys the fundamental concepts underlying multicellularity with an emphasis on the molecular basis of multicellular biological systems and their functional integration into coherent wholes. The structural and functional specialization in multicellular organisms will be discussed by highlighting common and specific functions in fungi, plants, and animals (including humans).

Objective: 1. Students can describe advantages and challenges associated with being multicellular and outline independent solutions that organisms have developed to cope with the challenges of complex multicellularity
2. Students can explain how the internal and external structures of fungi, plants and animals function to support survival, growth, behavior, and reproduction.
3. Students can explain the basic pathways and mechanisms of cellular communication regulating cellular behavior (cell adhesion, metabolism, proliferation, reproduction, development).
4. Students can describe how a single cell develops from one cell into many, each with different specialized functions.

Content: The lecture introduces the structural and functional specialization in fungi, plants and animals, including humans. After providing an overview on the diversity of eukaryotic organisms, the lecture will discuss how fungi, plants, animals and humans have evolved structures and strategies to cope with the challenges of multicellularity. The molecular basis underlying communication, coordination and differentiation will be conveyed and complemented by key aspects of reproduction, metabolism development, and regeneration. Topics include form and function of fungi and plants, human anatomy and physiology, metabolism, cell signaling, adhesion, stem cells, regeneration, reproduction, and development.

Campbell “Biology”, 11th Edition

Prerequisites / notice: Some lecture are held in English.

376-0151-00L Anatomy and Physiology I

Abstract: Basic knowledge of the anatomy and physiology of tissues, of the embryonal and postnatal development, the sensory organs, the neuro-muscular system, the cardiovascular system and the respiratory system.

Objective: Basic knowledge of human anatomy and physiology basics of clinical pathophysiology

Content: Anatomy and Physiology I (fall term):
- Basics of cytology, histology, embryology; nervous system, sensory organs, muscles, cardiovascular system, respiratory system

Anatomy and Physiology II (spring term):
- digestive tract, endocrine organs, metabolism and thermoregulation, skin, blood and immune system, urinary system, circadian rhythm, reproductive organs, pregnancy and birth.
**Pharmaceutical Analytics I**

**Abstract**
This course provides the basic concepts of pharmaceutical analytics in the context of pharmacopeial regulation by Ph. Eur and Ph. Helv.

**Objective**
Summarize the structure of the Ph. Eur.
Summarize the most important pharmacopoeias and their commonalities and differences (USP, JP, Ph.Eur., Ph. Helv.)
Discuss the structure of a monograph
Explain qualification of instruments and validation of methods
Explain and compare most important analytical techniques for pharmacies and pharmaceutical industry

**Content**
Knowledge in pharmaceutical analytics to fulfill regulatory requirements in pharmaceutical industry based on the pharmacopeia in force.
Focus is set on method validation, equipment qualification, identification of functional groups and content determination of active pharmaceutical ingredients and excipients.

**Lecture notes**
The slides of the lectures will be provided.

**Literature**
Instrumentelle Analytik, G. Rücker, M. Neugebauer, G.G. Willems; Deutscher Apotheker Verlag, Stuttgart
Arzneistoffanalyse; H. J. Roth, K. Eger, R. Troschütz; Deutscher Apotheker Verlag, Stuttgart
Introduction to Pharmaceutical Chemical Analysis; S.H. Hansen, S. Pedersen-Bjergaard, K. Rasmussen; Wiley & Sons

**Prerequisites / notice**
Requirements for the practical course Pharmaceutical Analytics:

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**Laboratory Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
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<td>529-0229-00L</td>
<td>Practical Course Organic Chemistry (for Students of Biology and Pharmaceutical Sciences)</td>
<td>O</td>
<td>8 credits</td>
<td>12P</td>
<td>C. Thilgen, Y. Yamakoshi</td>
</tr>
</tbody>
</table>

**Abstract**
Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography)
Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses).

**Objective**
Learn the basic techniques for the preparation and purification of organic compounds.
Learn to take accurate notes of the experiments and to write reports.
Deepen the understanding of reaction mechanisms.

**Content**
Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography).
Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses) from the following classes of reactions: 1. nucleophilic substitution at C(sp3), 2. elimination or electrofacic addition to C=C, 3. electrophilic aromatic substitution, 4. oxidation, 5. reduction, 6. Grignard reaction, 7. synthesis of a carboxylic acid derivative, 8. Aldol-, Claisen-, Mannich-, Michael reaction or Robinson annulation.

**Lecture notes**
Documents will be handed out at the beginning of the course.

**Literature**
1) P. Wörnel, M. Bitzer, U. Claus, H. Felber, M. Hüb, B. Vollenweider; Laborpraxis (Bd. 1: Einführung, allgemeine Methoden; Bd. 2: Messmethoden; Bd. 3: Trennungsmethoden; Bd. 4: Analytische Methoden); Birkhäuser Verlag; Basel; 1990.

**Prerequisites / notice**
The basic reactions of Organic Chemistry and their mechanisms should be known and the corresponding exam have been passed (cf. course 529-1012-00L Organic Chemistry II for Students of Biology, Pharmaceutical Sciences, and Health Sci. and Tech.).

As a prerequisite, all participants need to pass the "Safety Test HCI Chemie_V2 English" (see https://moodle-app2.let.ethz.ch). A printout of the certificate generated by the system needs to be presented to the teaching assistants prior to starting lab work.

**Safety concept:** https://chab.ethz.ch/studium/bachelor1.html

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**Third Year Courses**

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**Core Courses**

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<tr>
<td>535-0230-00L</td>
<td>Medicinal Chemistry I</td>
<td>O</td>
<td>2 credits</td>
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**Abstract**
The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical roles underlying ligand-target interactions will be discussed and illustrated with examples.

**Objective**
Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.

**Content**
Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions.
The lecture is centered around the discussion of medicinal plants and herbal medicines and their common medical applications. The main areas addressed in the lecture are (a) the structure and biosynthesis of plant constituents (i.e. plant-derived natural products) and (b) the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (herbal medicines based on plant extracts as well as isolated natural products). The basic pathways for the biosynthesis of the most important classes of plant-derived natural products are discussed in detail. Likewise, the molecular basis of the pharmacological effects of herbal extracts (and derived herbal medicines) and their individual constituent components (isolated natural products) is broadly addressed. As part of this discussion the availability of clinical data (or lack thereof) to support specific clinical applications of herbal medicines will be repeatedly highlighted. Potential risks associated with the use of herbal medicines are discussed for selected cases. The lecture is structured according to the major classes of natural products prevalent in medicinal plants and herbal medicines: Carbohydrates, lipids, terpenes, phenolic compounds, alkaloids, essential oils.

Lecture notes
Will be provided in parts before each individual lecture.

Literature

Prerequisites / notice
Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.
Objective

Students
• Are able to analyse, present and discuss common case studies from the pharmacist's practice, based on their basic knowledge in pharmacology.
• deepen their knowledge of therapeutic substance classes and therapy guidelines.
• are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to undesirable other effects and interactions).
• are able to compare different drugs and derive their therapy-relevant characteristics.

Content

Pharmaceutical case studies from different therapeutical fields comprehend following subject areas:
• Indication
• Dosage Form
• Adverse Drug Reactions
• Interactions
• Contraindications

Lecture notes

Is made available via Moodle.

Literature

As stated in the cases.

Prerequisites / notice

The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and discussed in plenary.

Fostered competencies

Subject-specific Competencies
Concepts and Theories not assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Self-presentation and Social Influence not assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

Abstract
The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on important methods and technologies and their application for genomic, transcriptomic and proteomic analyses in human biology.

Objective

The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomic, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

Content

I) Genomics and transcriptomics
Methods and Techniques:
• Recombinant DNA technology
• Next generation sequencing methods, sequencing of genomes
• CRISPR technology
Application to human biology:
• Functional genomics/transcriptomics
• Principles of cancer, genetic diseases
• Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

II) Proteomics
Methods and Techniques:
• Protein cloning and expression
• The antibody molecule
• Measurement and determination of biomolecular interactions
• Protein characterization and engineering
• Modifications and radioactive labelling
Application to human biology:
• Protein therapeutics
• Proteomic approaches for identification of novel disease-related targets and biomarkers

III) Drug discovery: Protein-based libraries
•Immune repertoire mining
•Display and selection technologies
1. antibody phage display
2. other polypeptide display technologies
3. small-molecules display: DNA-encoded chemical libraries

Lecture notes

The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Decision-making assessed
Problem-solving assessed

Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

Abstract
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Objective
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Content
Chapters 1 - 11 of the Janeway's ImmunoBiology, by Kenneth Murphy (9th Edition; Garland).
Abstract
Thorough knowledge of major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

Objective
Thorough knowledge of all major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

Content
Basics and principles of clinical microbiology:
- host-pathogen interaction
- symptoms and diagnosis of major bacterial pathogens
- therapeutic regimens commonly used against bacterial disease
- major aspects of medical mycology, virology and parasitology
- epidemiology

Literature
- Madigan M. T. et al., Brock Mikrobiologie, Pearson, 14. aktualisierte Auflage 2015

Prerequisites / notice
Basic knowledge of biochemistry, general microbiology, immunology

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Abstract
Molecular imaging in drug development
- Radiopharmaceutical syntheses
- Knowledge of the physical principles of radioactivity
- Structure and function of radiopharmaceuticals
- Examples of application in diagnosis and therapy in humans
- Targeted radionuclide therapy

Objective
- The students know and are able to describe the different imaging procedures in medicine, especially PET and SPET.
- At the end of the lecture, the students are able to explain and describe the physical basics in connection with radioactivity and the different types of radioactive radiation that are relevant in radiopharmacy and nuclear medicine.
- The students know how radionuclides can be produced and extracted.
- The students can describe the structure and function of radiopharmaceuticals and are able to develop strategies for the design of new radiopharmaceuticals.
- The students know selected examples of clinically relevant radiopharmaceuticals and can explain the structure and mechanism of action.
- The students can discuss and apply the principles of internal dosimetry of systemically applied radiopharmaceuticals using selected examples.

Content
Introduction to molecular imaging,
Radioactive decay, radiation and radionuclides relevant in nuclear medicine.
Radionuclide generators
Radiopharmaceutical synthesis strategies
Heart, brain and tumour diagnostics with radiopharmaceuticals
Kinetic modelling with radiopharmaceuticals
Tumour therapy with radiopharmaceuticals
Dosimetry of radiopharmaceuticals
Practical aspect of nuclear medicine and radiopharmacy

Literature
Book Title: Fundamentals of Nuclear Pharmacy
Authors Gopal B. Saha
DOI https://doi.org/10.1007/978-3-319-57580-3.

Book Title: Radiopharmaceuticals
Book Subtitle: A Guide to PET/CT and PET/MRI
Editors Ferdinando Calabria, Orazio Schillaci
DOI https://doi.org/10.1007/978-3-030-27779-6.

Book Title: Radiopharmaceutical Chemistry
Editors Jason S. Lewis, Albert D. Windhorst, Brian M. Zeglis
DOI https://doi.org/10.1007/978-3-319-98947-1.

Prerequisites / notice
Prerequisites: basic knowledge in physics and chemistry

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 1833 of 2416
Knowledge of experimental methods in drug discovery and development

The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

C. Steuer, U. Quitterer

Scripts
Solving analytical problems; Development and interpretation of analytical methods.

A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

Title
Solving analytical problems. Development and interpretation of analytical methods.

7P

Basic Training in Practical Medical Microbiology.

Practical Course in Medicinal Chemistry

Recommended reading:

J. Abd Alla

Lecturers

A. Lehner

Hours

3 credits

ECTS

7P

Abstract

This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

Objective

The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

Content

Topics include disease-relevant macroscopic, microscopic, pathobiochemical and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacoekinetics, side effects, toxicology, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

Lecture notes

A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

Literature

Klaus Aktories, Ulrich Förstermann, Franz Hofmann, Klaus Starke.
Allgemeine und spezielle Pharmakologie und Toxikologie.
Urban & Fischer (Elsevier, München)


The classic textbook in Pharmacology:

Goodman and Gilman’s The Pharmacological Basis of Therapeutics
Laurence Brunton, Bjorn Knollman, Randa Halil-Dandan.
ISBN-10: 125984739

or 14th Edition (expected Dec. 2022)

Prerequisites / notice

Voraussetzungen: Abschluss Grundstudium

Laboratory Courses

Number
535-0239-00L

Title
Practical Course in Medicinal Chemistry

Type
O

ECTS
3 credits

Hours
7P

Lecturers
J. Hall, C. Halin Winter, J. Scheuermann

Abstract

The course comprises experiments relating to concepts of medicinal chemistry including statistical processing, fitting of experimental data, computer modeling of protein structures, experimental measurement of affinity constants and kinetic dissociation constants for protein ligands. The chemical stability of a drug will be studied. Basic gene cloning and protein expression will be introduced.

Objectives

Knowledge of experimental methods in drug discovery and development

Content

Characterisation of the biophysical and biological properties of drugs.

Lecture notes

Scripts

Prerequisites / notice

Voraussetzungen: Abschluss Grundstudium

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Number
535-0166-00L

Title
Medical Microbiology Practical Course

Type
O

ECTS
1 credit

Hours
1G

Lecturers
A. Lehner

Abstract

Basic Training in Practical Medical Microbiology.

Objective

Analysis of simulated clinical specimens using classical methods of Medical Microbiology (microscopy, culture etc.). Main aims are the detection and identification of bacterial, mycobacterial and mycological pathogens as well as microbial susceptibility testing.

Content

Simulated patient specimens representing ca. 50 realistically constructed cases are analysed. The students work in groups and gain insight into the procedures in a routine clinical microbiological laboratory. Using a scriptum, they learn how to identify pathogens and test them for antimicrobial susceptibility. As single groups can work only on a fraction of the cases, results and observations are shared by short presentations through all groups.

Lecture notes

The scriptum (in German) will be distributed at the beginning of the course. It contains all protocols necessary for the practical work into the procedures in a routine clinical microbiological laboratory. Using a scriptum, they learn how to identify pathogens and test them for antimicrobial susceptibility. As single groups can work only on a fraction of the cases, results and observations are shared by short presentations through all groups.

Prerequisites / notice

Requirements:
Registration for the course until 15 October;
Attendance of the lecture Medicinal Microbiology in the same semester or earlier;" Basic skills in careful laboratory work.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Number
535-0219-00L

Title
Laboratory Course in Pharmaceutical Analytics

Type
O

ECTS
4 credits

Hours
7P

Lecturers
C. Steuer

Abstract

Solving analytical problems; Development and interpretation of analytical methods.

Objective

Solving analytical problems; Development and interpretation of analytical methods.

Content

Solving analytical problems, Development and interpretation of analytical methods.

Literature

Skript Pharmazeutische Analytik Praktikum

Prerequisites / notice

Requirements:
SR 2004: 2 credits Analytical Chemistry (529-1041-00), lecture Pharmaceutical Analytics
SR 2013: 6 credits Analytics/Pharmaceutical Analytics or 36 credits of compulsory lectures 2nd year.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

Electives

Wählfächer werden aus der Kategorie Kompensationsfächer gewählt.

Bachelor Studies (Programme Regulations 2013)
Laboratory Courses 2nd Year

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<th>Lecturers</th>
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<tr>
<td>529-0229-00L</td>
<td>Practical Course Organic Chemistry (for Students of Biology and Pharmaceutical Sciences)</td>
<td>O</td>
<td>8 credits</td>
<td>12P</td>
<td>C. Thilgen, Y. Yamakoshi</td>
</tr>
</tbody>
</table>

Abstract

Analytical part: basic operations for the separation of mixtures of organic compounds (recrystallization, distillation, extraction, chromatography).

Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses).

Objective

Learn the basic techniques for the preparation and purification of organic compounds.

Learn to take accurate notes of the experiments and to write reports.

Deepen the understanding of reaction mechanisms.

Content

Synthetic part (main part): at least 8 synthetic steps (one- or two-step syntheses) from the following classes of reactions: 1. nucleophilic substitution at C(sp3), 2. elimination or electrophilic addition to C=C, 3. electrophilic aromatic substitution, 4. oxidation, 5. reduction, 6. Grignard reaction, 7. synthesis of a carboxylic acid derivative, 8. Aldol-, Claisen-, Mannich-, Michael reaction or Robinson annulation.

Safety concept: https://chab.ethz.ch/studium/bachelor1.html

As a prerequisite, all participants need to pass the "Safety Test HCI Chemie_V2 English" (see https://moodle-app2.let.ethz.ch). A printout of the certificate generated by the system needs to be presented to the teaching assistants prior to starting lab work.

Fostered competencies

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<tr>
<th>Subject-specific Competencies</th>
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<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<td>Media and Digital Technologies</td>
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<td>Sensitivity to Diversity</td>
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Third Year

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<tr>
<td>535-0230-00L</td>
<td>Medicinal Chemistry I</td>
<td>O</td>
<td>2 credits</td>
<td>2V</td>
<td>J. Hall</td>
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</table>

Abstract

The lectures give an overview of selected drugs and the molecular mechanisms underlying their therapeutic effects in disease. The historical and modern-day methods by which these drugs were discovered and developed are described. Structure-function relationships and the biophysical rules underlying ligand-target interactions will be discussed and illustrated with examples.

Objective

Basic understanding of therapeutic agents with respect to molecular, pharmacological and pharmaceutical properties.
Content: Molecular mechanisms of action of drugs. Structure function and biophysical basis of ligand-target interactions

Lecture notes: Will be provided in parts before each individual lecture.

Literature:

Prerequisites/notice: Requirements: Knowledge of physical and organic chemistry, biochemistry and biology.

Attendance of Medicinal Chemistry II in the spring semester.

### 535-0421-00L Galenical Pharmacy I

**Abstract**
Principles and technologies for the manufacturing of dosage forms and drug delivery systems. Knowledge of pharm. excipients, materials, containers, liquid and semi-solid dosage forms, their production, function, quality and application. Comprehension of molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in dosage forms.

**Objective**
Knowledge of the most important pharmaceutical excipients, materials, containers, liquid and semi-solid dosage forms, of their production, function, quality, stability and application. Comprehension of the molecular interactions in solution and colloidal systems. Comprehension of interfacial phenomena and stabilization measures in disperse dosage forms.

**Content**
Introduction and overview of important fundamentals, principles and technologies for the development and manufacturing of dosage forms and drug delivery systems. Overview of the most important pharmaceutical excipients and polymers, their structure, properties and processing; importance of materials properties for containers. Pharmaceutical solvents, fundamentals of solubility and solubilization of drugs. Water treatment processes, sterilization techniques and quality requirements of pharmaceutical water. Parenteral dosage forms and liquid ophthalmics. Surfactants, micelle formation and colloidal systems. Liquid suspensions and emulsions. Stabilization measures in dosage forms.

**Literature**

**Prerequisites/notice**
Language: German and English

**Fostered competencies**

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<td>Adaptability and Flexibility</td>
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### 535-0521-00L Pharmacology and Toxicology I

**Abstract**
This two-semester lecture course provides a detailed understanding of the fundamentals of drug action and the therapeutic use of important classes of drugs. The lectures are intended for students of pharmaceutical sciences.

**Objective**
The lectures provide a comprehensive survey of pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects.

**Content**
Topics include disease-relevant macroscopic, microscopic, pathobiochemical and functional disturbances of specific organs and organ systems. The lectures integrate disease pathology with mechanisms of drug action, usage, metabolism, pharmacokinetics, side effects, toxicology, contraindications and dosage of relevant drugs. Basic principles of clinical pharmacology and pharmacotherapy will be covered.

**Lecture notes**
A script is provided for each lecture. Scripts define important course contents but do not replace the lectures.

**Literature**

The classic textbook in Pharmacology:

or 14th Edition (expected Dec. 2022)
The lecture is centered around the discussion of medicinal plants and herbal medicines and their common medical applications. The main gene technology assessed not assessed

The understanding of the biosynthesis of plant-derived natural products. Acquisition of fundamental knowledge on the medical applications

Is provided in parts before each lecture (electronically as pdf) and also available on the Ilias platform via My Studies.

Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:

• Indication
• Dosage Form
• Adverse Drug Reactions
• Interactions
• Contraindications

As stated in the cases.

The course places the basic pharmaceutical knowledge acquired so far in an applied therapeutic context and fosters interdisciplinary

The lecture takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and
discussed in plenary.

Common pharmaceutical case studies, as they can occur in the professional everyday life of a pharmacist, are worked out in group works, presented and discussed.

As for the discussion the availability of
clinical data (or lack thereof) to support specific clinical applications of herbal medicines will be repeatedly highlighted. Potential risks

Pharmaceutical Cases ■ O 1 credit 1G D. Stämpfli, S. Erni, E. Kut Bacs, P. Obrist

Students
• Are able to analyse, present and discuss common case studies from the pharmacist's practice, based on their basic knowledge in pharmacology.
• deepen their knowledge of therapeutic substance classes and therapy guidelines.
• are able to analyse the pharmacological profiles of selected drugs in a therapeutic context (e.g., with regard to undesirable other effects and interactions).
• are able to compare different drugs and derive their therapy-relevant characteristics.

Pharmaceutical case studies from different therapeutic fields comprehend following subject areas:

• Indication
• Dosage Form
• Adverse Drug Reactions
• Interactions
• Contraindications

Lecture notes
Is made available via Moodle.

Literature
As stated in the cases.

Prerequisites / notice
The lecture Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

The course takes place weekly. For each lesson, group work is prepared and submitted in advance, presented by one group at a time, and
discussed in plenary.

The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on

Objective
Fostered competencies
Subject-specific Competencies
Concepts and Theories not assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Self-presentation and Social Influence not assessed
Critical Thinking assessed

Personal Competencies

535-0525-00L Pharmaceutical Biology O 3 credits 2V B. Pfeiffer

Abstract
The structure and biosynthesis of plant constituents and the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (extract-based herbal medicines; isolated natural products) are discussed. Areas of focus are (a) major biosynthetic pathways for plant-derived natural products, (b) pharmacological effects of herbal extracts, and (c) molecular mechanisms of action.

Objective
The understanding of the biosynthesis of plant-derived natural products. Acquisition of fundamental knowledge on the medical applications of important herbal medicines and of isolated natural products (general disease areas, molecular constituents of medicinal plants and herbal medicines in general, molecular constituents responsible for pharmacological activity, possible mechanisms of action, available clinical data to support medical use).

Content
The lecture is structured according to the major classes of natural products prevalent in medicinal plants and herbal medicines: Carbohydrates, lipids, terpenes, phenolic compounds, alkaloids, essential oils.

The lecture is centered around the discussion of medicinal plants and herbal medicines and their common medical applications. The main areas addressed in the lecture are (a) the structure and biosynthesis of plant constituents (i.e. plant-derived natural products) and (b) the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (herbal medicines based on plant extracts as well as isolated natural products). The basic pathways for the biosynthesis of the most important classes of plant-derived natural products are discussed in detail. Likewise, the molecular basis of the pharmacological effects of medicinal plant extracts (and derived herbal medicines) and their individual constituent components (isolated natural products) is broadly addressed. As part of this discussion the availability of clinical data (or lack thereof) to support specific clinical applications of herbal medicines will be repeatedly highlighted. Potential risks associated with the use of herbal medicines are discussed for selected cases.

Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

Lecture notes
Is provided in parts before each lecture (electronically as pdf) and also available on the Ilias platform via My Studies.

Literature
- There is no English translation of the above textbook (or any reasonably equivalent text). Students intending to take the exam for the course and are not sufficiently proficient in German should contact the lecturer before the start of the course.

Prerequisites / notice
Requirements: Lecture courses in basic organic chemistry, biochemistry, and biology


Abstract
The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on

Objective
The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomics, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.

535-0333-00L Pharmaceutical Cases ■ O 1 credit 1G D. Stämpfli, S. Erni, E. Kut Bacs, P. Obrist

Abstract
The course places the basic pharmaceutical knowledge acquired so far in an applied therapeutic context and fosters interdisciplinary

Objective
Fostered competencies
Subject-specific Competencies
Concepts and Theories not assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Self-presentation and Social Influence not assessed
Critical Thinking assessed

Personal Competencies

535-0525-00L Pharmaceutical Biology O 3 credits 2V B. Pfeiffer

Abstract
The structure and biosynthesis of plant constituents and the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (extract-based herbal medicines; isolated natural products) are discussed. Areas of focus are (a) major biosynthetic pathways for plant-derived natural products, (b) pharmacological effects of herbal extracts, and (c) molecular mechanisms of action.

Objective
The understanding of the biosynthesis of plant-derived natural products. Acquisition of fundamental knowledge on the medical applications of important herbal medicines and of isolated natural products (general disease areas, molecular constituents of medicinal plants and herbal medicines in general, molecular constituents responsible for pharmacological activity, possible mechanisms of action, available clinical data to support medical use).

Content
The lecture is structured according to the major classes of natural products prevalent in medicinal plants and herbal medicines: Carbohydrates, lipids, terpenes, phenolic compounds, alkaloids, essential oils.

The lecture is centered around the discussion of medicinal plants and herbal medicines and their common medical applications. The main areas addressed in the lecture are (a) the structure and biosynthesis of plant constituents (i.e. plant-derived natural products) and (b) the pharmacological effects and therapeutic applications of biogenic drugs of plant origin (herbal medicines based on plant extracts as well as isolated natural products). The basic pathways for the biosynthesis of the most important classes of plant-derived natural products are discussed in detail. Likewise, the molecular basis of the pharmacological effects of medicinal plant extracts (and derived herbal medicines) and their individual constituent components (isolated natural products) is broadly addressed. As part of this discussion the availability of clinical data (or lack thereof) to support specific clinical applications of herbal medicines will be repeatedly highlighted. Potential risks associated with the use of herbal medicines are discussed for selected cases.

Pharmacology and Toxicology I (535-0521-00L) must be attended in parallel to or prior to this course.

Lecture notes
Is provided in parts before each lecture (electronically as pdf) and also available on the Ilias platform via My Studies.

Literature
- There is no English translation of the above textbook (or any reasonably equivalent text). Students intending to take the exam for the course and are not sufficiently proficient in German should contact the lecturer before the start of the course.

Prerequisites / notice
Requirements: Lecture courses in basic organic chemistry, biochemistry, and biology


Abstract
The course gives a description and summary of the field of gene technology and its pharmaceutical applications. The course focuses on

Objective
The course gives an overview of current state-of-the art and advancement in the fields of gene technology. Herein, the course focuses on genomics, transcriptomic and proteomic analysis and their uses in drug discovery and biomedical applications. The course is structured into lectures and practical examples drawn from the research field. Upon completion, the students are familiar and know current state-of-the art of methods and applications, but are also able to classify, contrast and apply different strategies and methods within the field of gene technology. The course is suited for advanced undergraduate and early graduate students in pharmaceutical sciences or related fields.
I) Genomics and transcriptomics

Methods and Techniques:
- Recombinant DNA technology
- Next generation sequencing methods, sequencing of genomes
- CRISPR technology

Application to human biology:
- Functional genomics/transcriptomics
- Principles of cancer, genetic diseases
- Therapies: cell-based therapies/gene therapies/DNA and RNA vaccination

II) Proteomics

Methods and Techniques:
- Protein cloning and expression
- The antibody molecule
- Measurement and determination of biomolecular interactions
- Protein characterization and engineering
- Modifications and radioactive labelling

Application to human biology:
- Protein therapeutics
- Proteomic approaches for identification of novel disease-related targets and biomarkers

III) Drug discovery: Protein-based libraries

- Immune repertoire mining
- Display and selection technologies
  1. antibody phage display
  2. other polypeptide display technologies
  3. small-molecules display: DNA-encoded chemical libraries

Lecture notes

The lecture series follows the above-described content, and the students are provided with the lecture slides and additional notes. The additional notes are needed for the in-depth study of the individual topics, and to set the frame and content of the in-class group work of the chosen examples.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Decision-making
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking

535-0830-00L Pharmaceutical Immunology O 2 credits 2G C. Halin Winter, V. Collado Diaz

Abstract
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Objective
Get Students familiar with basic Immunological concepts of pharmaceutical relevance.

Content
Chapters 1 - 11 of the Janeway’s ImmunoBiology, by Kenneth Murphy (9th Edition; Garland).

Literature
Janeway’s ImmunoBiology, by Kenneth Murphy (9th Edition).

Paperback [www.garlandscience.com]

535-0210-00L Radiopharmaceutical Chemistry O 2 credits 2V R. Schibli, L. Mu

Abstract
- Molecular imaging in drug development
- Radiopharmaceutical syntheses
- Knowledge of the physical principles of radioactivity
- Structure and function of radiopharmaceuticals
- Examples of application in diagnosis and therapy in humans
- Targeted radionuclide therapy

Objective
- The students know and are able to describe the different imaging procedures in medicine, especially PET and SPET.
- At the end of the lecture, the students are able to explain and describe the physical basics in connection with radioactivity and the different types of radioactive radiation that are relevant in radiopharmacy and nuclear medicine.
- The students know how radionuclides can be produced and extracted.
- The students can describe the structure and function of radiopharmaceuticals and are able to develop strategies for the design of new radiopharmaceuticals.
- The students know selected examples of clinically relevant radiopharmaceuticals and can explain the structure and mechanism of action.
- The students can discuss and apply the principles of internal dosimetry of systemically applied radiopharmaceuticals using selected examples.

Content
Introduction to molecular imaging.
Radioactive decay, radiation and radionuclides relevant in nuclear medicine.
Radionuclide generators
Radiopharmaceutical synthesis strategies
Heart, brain and tumour diagnostics with radiopharmaceuticals
Kinetic modelling with radiopharmaceuticals
Tumour therapy with radiopharmaceuticals
Dosimetry of radiopharmaceuticals
Practical aspect of nuclear medicine and radiopharmacy

Literature
Book Title: Fundamentals of Nuclear Pharmacy Authors Gopal B. Saha
DOI https://doi.org/10.1007/978-3-319-57980-3.

Book Title: Radiopharmaceuticals Book Subtitle A Guide to PET/CT and PET/MRI Editors Ferdinando Calabria, Orazio Schillaci
DOI https://doi.org/10.1007/978-3-030-27779-6.

Book Title Radiopharmaceutical Chemistry Editors Jason S. Lewis
Albert D. Windhorst, Brian M. Zeglis
DOI https://doi.org/10.1007/978-3-319-98947-1.

Access via ETH Library
### Prerequisites / notice

**Prerequisites:** basic knowledge in physics and chemistry

## Fostered competencies

### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

### Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

### Personal Competencies

- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

### Laboratory Courses 3rd Year

#### Number

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0165-00L</td>
<td>Clinical Microbiology</td>
<td>O</td>
<td>1 credit</td>
<td>1V</td>
</tr>
<tr>
<td>535-0219-00L</td>
<td>Laboratory Course in Pharmaceutical Analytics</td>
<td>O</td>
<td>4 credits</td>
<td>7P</td>
</tr>
<tr>
<td>535-0166-00L</td>
<td>Medical Microbiology Practical Course</td>
<td>O</td>
<td>1 credit</td>
<td>1G</td>
</tr>
<tr>
<td>535-0239-00L</td>
<td>Practical Course in Medicinal Chemistry</td>
<td>O</td>
<td>3 credits</td>
<td>7P</td>
</tr>
</tbody>
</table>

#### Abstract

Thorough knowledge of major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

#### Objective

Thorough knowledge of all major pathogens involved in infectious diseases; principles of laboratory diagnosis of pathogenic bacteria and fungi.

#### Content

- Basics and principles of clinical microbiology:
  - host-pathogen interaction
  - symptoms and diagnosis of major bacterial pathogens
  - therapeutic regimens commonly used against bacterial disease
  - major aspects of medical mycology, virology and parasitology
- epidemiology

#### Literature

- Madigan M.T. et al., Brock Mikrobiologie, Pearson, 14. aktualisierte Auflage 2015

#### Prerequisites / notice

Basic knowledge of biochemistry, general microbiology, immunology

#### Laboratory Courses 3rd Year

Respective lectures must be attended before/together with the Laboratory Courses. Special schedule for the Laboratory Courses.
The course comprises experiments relating to concepts of medicinal chemistry including statistical processing, fitting of experimental data, computer modeling of protein structures, experimental measurement of affinity constants and kinetic dissociation constants for protein ligands. The chemical stability of a drug will be studied. Basic gene cloning and protein expression will be introduced.

Objective
Knowledge of experimental methods in drug discovery and development

Content
Characterisation of the biophysical and biological properties of drugs.

Lecture notes
Scripts

Literature
Original literature

Prerequisites / notice
Requirements: Laboratory course in Pharmaceutical Analytics; Lecture Medicinal Chemistry I in the same semester or earlier.

S. Ruppen

In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs.

After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and medicines and to place them in a temporal context. They can list sources for working on questions from the history of pharmacy and evaluate their advantages and disadvantages. This enables them to confidently describe the importance of pharmacy as an independent, supporting pillar of the health system, the history of which has many interfaces with medicine, science, social and cultural history.

Social position of pharmacists in society and the legal conditions in different epochs are also discussed. It explains what influence the pharmacists had on the development of the pharmaceuticals, but again the pharmaceuticals on the development of the pharmacists. For this purpose, it is shown how much the meaning, the nature, the type and the composition of the pharmacist and the knowledge about them changed over time.


Lab exercises will be provided.

Literature

Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies not assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

535-0015-00L

History of Pharmacy

W 1 credit 1V

S. Ruppen

535-0360-00L

Evidence Based Phytotherapy

W 1 credit 1V

K. Berger Büter

Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed.

Compensatory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0344-00L</td>
<td>From Ethnopharmacy to Molecular Pharmacognosy</td>
<td>W</td>
<td>1 credit</td>
<td>1V</td>
<td>B. Frei Haller, A. Lardos</td>
</tr>
<tr>
<td>Abstract</td>
<td>Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.</td>
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</tr>
<tr>
<td>Content</td>
<td>Introduction into ethnopharmacy and related disciplines; definitions of terms, working methods, research projects, bioprospecting. Traditional medicinal plants of different cultures and their role in modern Western medicine (rational application of traditional uses). Historical data as sources for drug research. Today's &quot;fashion plants.&quot; Empirical, traditional knowledge versus Evidence Based Medicine. The role of biodiversity (CBD, Rio 1992; Nagoya, 2010) and problems associated with drug discovery from natural products. Screening strategies for drug discovery (random screening versus screening based on cultural, ecological, ethnopharmaceutical, chemotaxonomic criteria). Traditional knowledge in relation to the fight against malaria and its implementation in research, product development and development cooperation. Introduction to and selected examples of herbal drugs and poisons, mode of action, and their ethnopharmacological importance. Critical analysis of bioprospecting as a drug discovery strategy.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts will be provided.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.</td>
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</tr>
</tbody>
</table>

| 535-0360-00L | Evidence Based Phytotherapy | W 1 credit | 1V | K. Berger Büter |
| Number   | Title                                           | Type | ECTS | Hours | Lecturers                        |
| 535-0360-00L | Evidence Based Phytotherapy | W 1 credit | 1V | K. Berger Büter |
| Abstract | Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed. |

Autumn Semester 2022
Vitamins in Health and Disease

Objective

Students should learn the importance of rational (= evidence-based) pharmacotherapy with herbal extracts. They should know the most important aspects of herbal medicinal products:
- How are interesting development candidates identified. What are the strategies?
- What are the regulatory requirements (Traditional use, well-established use, new herbal entities)?
- Efficacy determination (animal/human studies, biomarkers)
- Pharmacokinetics
- Safety (toxicity, adverse effects, interactions)
- Pharmaceutical quality
- Origin of the plant raw material (wild collections, cultivation)
- Ensuring consistent quality
- Which extraction methods?

The following important plants and products will be presented and critically discussed as examples (see program below)

Content

1) 21.09.2
Introduction:
Quality of medicinal plant, finished products, monographs (Commission E, ESCOP, HMPC), differences in terms of registration status and requirements: traditional use, well established use and new herbal entities; extracts, quality medicinal drugs.

2) 28.9.2022:
Phases of clinical development, basic concepts of evidence-based medicine.
Hypericum perforatum

3) 05.10.2022 - no face-to-face lecture (lecture will be pre-recorded)
Silybum marianum; Pelargonium spp.

4) 12.10.2022
Phytotherapy for functional intestinal disorders; Harpagophytum spp.

5) 19.10.2022:
Lavandula oleum; Echinacea spp.

6) 26.10.2022:
Cimicifuga racemosa; Cannabis sativa

7) 02.11.2022:
Exam (Multiple Choice).

Lecture notes

The selection of plants may be subject to change.

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
- Personal Competencies
  - Critical Thinking

Objective

The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products.

Content

Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested.

A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period.

The lecture 'Vitamins in Heath and Disease' will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

Lecture notes

Hand-outs will be distributed during the lecture (partly in English, partly in German).

Literature

- Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-8304-6071-8
- Book recommendation: reference books:
  - Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-8304-6071-8

Prerequisites

Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.


Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1841 of 2416
Abstract
Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.

Objective
Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:
- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs.
- the major types of protein-linked glycans and the biosynthetic pathways for their formation
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control).

Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper).

Students gain the ability to reflect on roles of glycosylation in various biological contexts.

Content
lecture plan:
1. Glycans - information carriers in biology and pharmacotherapy
2. Glucocerebrosidase and the biosynthesis of N-glycans
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
5. production and gCQA analysis of Glucocerebroside, monoclonal antibodies, glycoprotein hormone drugs - Glycoanalytics
6. EPO "the same but different"

Lecture notes
The slides used for the lectures will be provided online

Literature
- recent publications as cited/proposed on the lecture slides

Prerequisites / notice
Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Problem-solving assessed
Social Competencies
Communication assessed
Personal Competencies
Creative Thinking assessed
Critical Thinking assessed

535-0300-00L Molecular Mechanisms of Drug Actions and Targets

W 2 credits 1V J. Scheuermann

Abstract
On average one drug per year is withdrawn from the market. Using selected examples of such drug failures, the course aims at analyzing and discussing the present explanations of drug actions as well as the design and predictive power of animal models and clinical trials. In addition, the ethical, societal, and economical expectations in new drugs shall be reflected and discussed.

Objective
To develop a critical understanding of the relevance and limitations of the current approaches to explaining and anticipating drug effects.

Content
In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the limitations of an extremely reductionist view of atherosclerosis and it's prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success.

These are the topics of the present course. Using three particularly informative examples of drug failures, the problems encountered and the concepts and informative value of preclinical and clinical studies will be analyzed and discussed. Furthermore, the ethical, societal, and economical and political expectations in new drugs shall be reflected.

Lecture notes
Lecture slides and literature for reading and discussions will be available online.

Prerequisites / notice
Requirements: basic knowledge in Immunology, Medicinal Chemistry and Pharmacology. Ability to read and understand scientific publications written in English.

535-0423-00L Drug Delivery and Drug Targeting

W 2 credits 1.5V J.-C. Leroux

Abstract
The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.

Objective
The students dispose of an overview on current principles and systems for the controlled delivery and targeting of drugs. The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.

Content
The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.

Lecture notes
Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.

Literature


Further references will be provided in the course.
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Key skills
- On successful completion of the module the student should be able to
  - interpret and critically evaluate original research reports
  - apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice

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535-0022-00L Computer-Assisted Drug Design

Abstract
The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.

Objective
The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.

Content
The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening (docking, physics-based models).

Lecture notes
Script will be available.

Literature
Recommended textbooks:

376-0021-00L Materials and Mechanics in Medicine

Abstract
Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective.

Objective
Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content
Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes
course website on Moodle

Literature
Academic Press

376-1305-00L Development of the Nervous System (University of Zurich)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: BIO344

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Abstract
The lecture will cover molecular and cellular processes underlying the development of the nervous system (neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation). The importance of these processes in the context of developmental diseases is discussed.

Objective
On successful completion of the module the student should be able to
- relate structure and function of the nervous system to its development - apply principles of molecular, cellular, and developmental biology to the development of the nervous system
- identify key steps in development underlying neurological syndromes and diseases

Key skills
On successful completion of the module the student should be able to
- interpret and critically evaluate original research reports
- apply knowledge and relate experimental approaches from molecular, cellular and developmental biology to the developing nervous system.

Content
The lecture will cover molecular and cellular processes underlying the development of the nervous system. After an introduction to structure and function of the nervous system, we will discuss neurogenesis, cell death, cell migration and differentiation, axon guidance and synapse formation. The importance of these processes in the context of developmental diseases will be discussed.

Lecture notes
Must be downloaded from OLAT: https://www.olat.uzh.ch/olat/dmz/ as BIO344

Literature
The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on OLAT.

Prerequisites / notice
BIO142 Developmental Biology, BIO143 Neurobiology
376-1305-01L  Neural Systems for Sensory, Motor and Higher Brain Functions

Information for UZH students: Enrolment to this course unit only possible at ETH. No enrolment to module BIO543 at UZH. Please mind the ETH enrolment deadlines for UZH students: https://www.ethz.ch/en/studies/non-degree-courses-special-students-special-students-university-of-zurich.html

Abstract The course covers the structure, plasticity and regeneration of the adult nervous system (NS) with focus on: sensory systems, cognitive functions, learning and memory, molecular and cellular mechanisms, animal models, and diseases of the NS.

Objective The aim is to give a deepened insight into the structure, plasticity and regeneration of the nervous system based on molecular, cellular and biochemical approaches.

Content The main focus is on the structure, plasticity and regeneration of the NS: biology of the adult nervous system; structural plasticity of the adult nervous system, regeneration and repair: networks and nerve fibers, regeneration, pathological loss of cells.

Literature The lecture requires reading of book chapters, handouts and original scientific papers. Further information will be given in the individual lectures and are mentioned on Moodle / OLAT.

376-1714-00L  Biocompatible Materials

Abstract Introduction to molecules used for biomaterials, molecular interactions between different materials and biological systems (molecules, cells, tissues). The concept of biocompatibility is discussed and important techniques from biomaterials research and development are introduced.

Objective The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes Handouts are deposited online (moodle).

Literature:

(available online via ETH library)

551-0313-00L  Microbiology (Part I)

Abstract Advanced lecture class providing a broad overview on bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Objective This concept class will be based on common concepts and introduce to the enormous diversity among bacteria and archaea. It will cover advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Content Advanced class covering the state of the research in bacterial cell structure, genetics, metabolism, symbiosis and pathogenesis.

Lecture notes Updated handouts will be provided during the class.

Literature Current literature references will be provided during the lectures.

Prerequisites / notice English

The lecture "Grundlagen der Biologie II: Mikrobiologie" is the basis for this advanced lecture.

551-0319-00L  Cellular Biochemistry (Part I)

Abstract Concepts and molecular mechanisms underlying the biochemistry of the cell, providing advanced insights into structure, function and regulation of individual cell components. Particular emphasis will be put on the spatial and temporal integration of different molecules and signaling pathways into global cellular processes such as intracellular transport, cell division & growth, and cell migration.

Objective The full-year course (551-0319-00 & 551-0320-00) focuses on the molecular mechanisms and concepts underlying the biochemistry of cellular physiology, investigating how these processes are integrated to carry out highly coordinated cellular functions. The molecular characterisation of complex cellular functions requires a combination of approaches such as biochemistry, but also cell biology and genetics. This course is therefore the occasion to discuss these techniques and their integration in modern cellular biochemistry.

Content The students will be able to describe the structural and functional details of individual cell components, and the spatial and temporal regulation of their interactions. In particular, they will learn to explain the integration of different molecules and signaling pathways into complex and highly dynamic cellular processes such as intracellular transport, cytoskeletal rearrangements, cell motility, cell division and cell growth. In addition, they will be able to illustrate the relevance of particular signaling pathways for cellular pathologies such as cancer.

Lecture notes Scripts and additional material will be provided during the semester. Please contact Dr. Alicia Smith for assistance with the learning materials. (alicia.smith@bc.biol.ethz.ch)

Literature Recommended supplementary literature (review articles and selected primary literature) will be provided during the course.

Prerequisites / notice To attend this course the students must have a solid basic knowledge in chemistry, biochemistry and general biology. The course will be taught in English.

752-1003-00L  Food Chemistry II

Abstract To familiarize with the structure, properties and reactivity of food constituents. To understand the relationship between the multiple chemical reactions and the quality of food.
Within the scope of this lecture you will learn the basic principles of trauma biomechanics. Based on examples from sports, you will get to know different mechanisms that can possibly result in injury. Investigating the background and cause of injury should allow you to assess the injury risk for sports activities. Furthermore you should be able to develop measures to prevent such injury.

The lectures Food Chemistry I and Food Chemistry II constitute a unit.

Content

The lectures Food Microbiology I and Food Microbiology II are offered in the Summer Semester.  The lectures are supplemented with handouts.

Objectives

1. History of Food Microbiology
   1.1. Short synopsis of foodborne microorganisms
   1.2. Spoilage of Foods
   1.3. Foodborne Disease
   1.4. Food Preservation
   2. Overview of Microorganisms in Foods
      2.1. Origin of foodborne Microorganisms
      2.2. Bacteria
      2.3. Yeasts
      2.4. Molds
      3. Biofilm Spoliation of Foods
      3.1. Intrinsic and Extrinsic Parameters
      3.2. Meats, Seafoods, Eggs
      3.3. Milk and Milk Products
      3.4. Vegetable and Fruit Products
      3.5. Miscellaneous (baked goods, nuts, spices, ready-to-eat products)
      3.6. Drinks and Canned Foods
   4. Foodborne Disease
      4.1. Significance and Transmission of Foodborne pathogens
      4.2. Staphylococcus aureus
      4.3. Gram-positive Sporeformers (Bacillus & Clostridium)
      4.4. Listeria monocytogenes
      4.5. Salmonella, Shigella, Escherichia coli
      4.6. Vibrio, Yersinia, Campylobacter
      4.7. Brucella, Mycobacterium
      4.8. Parasites
      4.9. Viruses and Bacteriophages
      4.10. Mycotoxins
      4.11. Bioactive Amines
      4.12. Miscellaneous (Antibiotic-resistant Bacteria, Biofilms)
   5. Food preservation
   6. Foodborne disease
   7. Microbial spoilage of foods

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download.

Literature

Selected (possibly changing) food chemistry topics (e.g. sweeteners, polysaccharides, from olive to margarine, etc.)

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1845 of 2416
Epidemiology and Prevention

The module Epidemiology and prevention follows an overall framework that describes the course of scientific discovery from the detection of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes

Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students. Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

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Functional Microorganisms in Foods

Objective

To understand the principles, roles and mechanisms of microorganisms with metabolic activities of high potential for application in traditional and functional foods, and for benefiting human health. This course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

Content

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Legal and protection issues related to functional foods
- Industrial biotechnology of flavor and taste development
- Safety of food cultures and probiotics

Lecture notes

Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Dietary Etiologies of Chronic Disease

Objective

To have the student gain understanding of the links between the diet and the etiology and progression of chronic diseases, including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Content

The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Lecture notes

There is no script. Powerpoint presentations will be made available on-line to students.

Epidemiology and Prevention

Objective

The overall module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Content

The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies.

Fostered competencies

- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed, Decision-making assessed, Problem-solving not assessed, Project Management not assessed
- Social Competencies: Communication not assessed
- Personal Competencies: Cooperation and Teamwork not assessed, Critical Thinking not assessed

Food Biotechnology

Objective

Basic information for understanding biotechnology applied to food processing will be presented. This will include a presentation of the physiology of important productive microorganisms used in food fermentations; microbial and fermentation kinetics, and design and operation of fermentation processes and bioreactors; and application of modern molecular tools for food biotechnology.
Objective
The main goal for this course is to provide students with basic information for understanding biotechnology applied to food processing. For the students, the aim will be:
- To understand the important role of microbial physiology and molecular tools for food biotechnology;
- To understand basic principles of fermentation biotechnology, with particular emphasis on metabolism and kinetics for food applications.

Content
Biotechnology has been defined as any technique that uses living organisms, or substances from those organisms, to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses. In this course, basic knowledge for understanding biotechnology as applied to food processing will be presented. This course builds on the application of principles learned from other basic courses in the Bachelor program, especially microbiology and microbial metabolism, molecular biology, biochemistry, physics and engineering. Students will learn about the physiology of important productive microorganisms (lactic acid bacteria, bifidobacteria, propionibacteria and fungi) used in food fermentations, closely related to applications in biotechnology. Microbial and fermentation kinetics, and design and operation of fermentations and bioreactors used for both research and industrial scale production of traditional foods and modern food ingredients will be presented. This part will be illustrated by examples of food fermentation processes, representative of specific challenges. Finally, the application of modern molecular tools to food biotechnology will be discussed.

Lecture notes
A copy of the power point slides from each lecture will be provided.

Literature
A list of references will be given at the beginning of the course for the different topics presented during the course.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

see Science in Perspective: Language Courses ETH/UZH

Pharmaceutical Sciences Bachelor - Key for Type

| W+ | Eligible for credits and recommended | Z | Courses outside the curriculum |
| W  | Eligible for credits                | Dr| Suitable for doctorate       |
| E- | Recommended, not eligible for credits | O | Compulsory                   |

Key for Hours

| V  | lecture | P | practical/laboratory course |
| G  | lecture with exercise | A | independent project |
| U  | exercise | D | diploma thesis |
| S  | seminar | R | revision course / private study |
| K  | colloquium | | |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Pharmacy Master

Core Courses I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences. Students work in small groups on a chosen topic, they write a mini-review and present their work on a one day symposium.

Objective
The main objectives of this course are:
- students develop their scientific reflection (Critical Thinking) and working skills by working independently on a relevant pharmaceutical topic
- students gain in-depth knowledge of the topic investigated
- students train their scientific writing and presentation skills
- students train their ability to plan a project and work in a team

Content
The Course Drug Seminar takes place during the first 7 weeks of the 1. Master semester. It is a compulsory course of the MSc Pharmacy curriculum and an elective course in the MSc PharmSciences.

The course provides a platform for the investigation, presentation and discussion of a topic with relevance to the field of pharmaceutical sciences.

During the course, students work in small teams on a topic of their choice and elaborate a written mini-review and an oral presentation. Each team is tutored by a lecturer of the Institute of Pharmaceutical Sciences. The work is mainly based on literature search / review, but may also involve conducting interviews or site visits, if appropriate. The final presentations of all groups will take place in the framework of a dedicated Symposium held in the middle of the semester.

Prerequisites / notice
Only for students of MSc Pharmacy and MSc Pharmaceutical Sciences.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>535-0011-00L</td>
<td>Pharmacology and Toxicology III</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>U. Quitterer, M. Arand, Y. Yamauchi</td>
</tr>
</tbody>
</table>

Abstract
The course is divided into two parts. The first part provides a detailed understanding of drugs and the pharmacotherapy of infectious diseases and cancer. The second part gives an overview of the field of pharmacogenomics and toxicogenomics with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

Objective
The course advances basic knowledge in pharmacology and toxicology. Special emphasis is placed on the interrelationship between pharmacological, pathophysiological and clinical aspects of drug therapy in the fields of infectious diseases and cancer. The course also provides an overview of the field of pharmacogenomics and toxicogenomics, with a special focus on the role of genetic polymorphisms in disease susceptibility, drug response and adverse effects.

Content
Topics include the pharmacology and pharmacotherapy of infectious diseases and cancer. In the field of pharmacogenomics and toxicogenomics, the course is focused on genetics, genome-wide association studies, examples of genetic variability of drug metabolism and drug responses, and the relevance of pharmacogenomics and toxicogenomics for clinical drug development.

Lecture notes
A script is provided for each lecture. The scripts define important and exam-relevant contents of the lectures. Scripts do not replace the lectures.

Literature
Recommended reading:
- The classic textbook in Pharmacology: Goodman and Gilman’s The Pharmacological Basis of Therapeutics
- or

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tbody>
<tr>
<td>535-0050-00L</td>
<td>Pharmacopepidemiology and Drug Safety</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>A. Burden, S. Russmann</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the principles, methods and applications of pharmacoepidemiology and drug safety. Drug safety in the pharmaceutical industry and regulatory authorities, but also for hospital and office pharmacists. Another focus is the evaluation and interpretation of pharmacoepidemiological drug safety studies in the medical literature and the evaluation of benefits vs. risks.

Objective
Objectives:
- To familiarize participants with the principle methods and applications of pharmacoepidemiology and drug safety that is relevant for industry, regulatory affairs, but also for clinical pharmacists in hospitals and office pharmacies.
- Perform independently a causality assessment of suspected adverse drug reactions in patients
- Study designs and biostatistics used for the quantitative evaluation of drug safety
- Setup of programs that can effectively reduce medication errors and improve drug safety in clinical practice, particularly in hospitals

Content
- Historical landmarks of drug safety
- Pharmacovigilance and causality assessment
- Drug safety in premarketing clinical trials
- Descriptive, cohort and case-control drug safety study designs; Data analysis and control of confounding
- Pharmacoepidemiology and regulatory decision making in drug safety; Risk management plans (RMPs)
- Medication errors, clinical pharmacology / clinical pharmacy
- Clinical Decision Support Systems, Interventional Pharmacoepidemiology
- Pharmacoepidemiological databases, ‘Big Data’
- Interactive discussion of many real-life examples for each topic

Lecture notes
This course will be a combination of formal lectures, group discussions and self-directed studies. Course material will be taught through seminars, case studies in small groups. Reading material and scripts will be provided for each week.
The course consists of two parts:

**Provided via myStudies.**

Documentation will be available before the lectures electronically.

**Type**

M. Hersberger

**Triage, Diagnostics, Therapy Support**

This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases. Students know and understand:

- the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.
- know the therapeutic guidelines, classes of active ingredients and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications).

**Content**

"Pharmaceutical Care" und "Health Care";

Häufigste Erkrankungen und Therapien der
- Allergologie
- Angiologie und Hämatologie
- Dermatologie
- Endokrinologie und Diabetologie
- Gastroenterologie
- Infektiologie
- Kardiologie
- Neurologie
- Ophthalmologie
- Otorhinolaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Grundlagen der Chiropraktischen Medizin und Physiotherapie.

**Lecture notes**

Provided via myStudies.

**Literature**

As stated in the lecture notes.

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535-0030-00L

**Therapeutic Proteins**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>535-0030-00L</td>
<td>Therapeutic Proteins</td>
<td>3</td>
<td>3G</td>
<td>C. Halin Winter, D. Neri</td>
</tr>
</tbody>
</table>

**Abstract**

In this course, various topics related to the development, GMP production and application of therapeutic proteins will be discussed. Furthermore, students will expand their training in pharmaceutical immunology and will be introduced to the basic concepts of pharmaceutical product quality management.

**Objective**

Students know and understand:

- basic mechanisms and regulation of the immune response
- the pathogenic mechanisms of the most important immune-mediated disorders
- the most frequently used expression systems for the production of therapeutic proteins
- the use of protein engineering tools for modifying different features of therapeutic proteins
- the mechanism of action of selected therapeutic proteins and their application
- basic concepts in the GMP production of therapeutic proteins

**Content**

The course consists of two parts:

In a first part, students will complete their training of pharmaceutical immunology (Chapter 13 - 16 Immunobiology VIII textbook). This part particularly focuses on the pathogenic mechanisms of immune-mediated diseases. Deepened knowledge of immunology will be relevant for understanding the mechanism of action of many therapeutic proteins, as well as for understanding one major concern related to the use of protein-based drugs, namely, immunogenicity.

The second part focuses on topics related to the development and application of therapeutic proteins, such as protein expression, protein engineering, reducing immunogenicity, and GMP production of therapeutic proteins. Furthermore, selected examples of approved therapeutic proteins will be discussed.

**Lecture notes**

Handouts to the lectures will be available for downloading under http://www.pharma.ethz.ch/scripts/index

**Literature**

- Janeway's Immunobiology, by Kenneth Murphy (9th Edition), Chapters 12-16
- Lecture Handouts
- Paper References provided in the Scripts
- EMEA Dossier for Humira

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535-0137-00L

**Clinical Chemistry II**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0137-00L</td>
<td>Clinical Chemistry II</td>
<td>1</td>
<td>1V</td>
<td>M. Hersberger</td>
</tr>
</tbody>
</table>

**Abstract**

Detailed knowledge on particular aspects of clinical chemistry and medical laboratory diagnostics concerning quality control, point-of-care analytics, analytics of kidney stones, tumor markers, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Objective**

Detailed knowledge on the implementation and interpretation of clinical laboratory diagnostic tests. Competence to interpret selected tests.

**Content**

Internal and external quality control, point-of-care analytics, analytics of kidney stones, use of tumor marker determinations, diagnosis of HIV and hepatitis, pharmacogenetics, thyroid function, bone metabolism and laboratory diagnosis of hypertension.

**Lecture notes**

Documentation will be available before the lectures electronically.

**Literature**

- Jürgen Hallbach, Klinische Chemie und Hämatologie für den Einstieg, Thieme Verlag
- Harald Renz, Praktische Labordiagnostik, de Gruyter Verlag
- Walter Guder, Das Laborbuch für Klinik und Praxis, Elsevier Verlag
- Lothar Thomas, Labor und Diagnose, TH Books
- William Marshall, Clinical Chemistry, Mosby Ltd.
- Alan H.B. Wu, Tietz, Clinical Guide to Laboratory Tests, Saunders

**Prerequisites / notice**

Requirement: basic knowledge in clinical chemistry and laboratory diagnostics

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**Core Courses (Clinical Subjects)**

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>

**Abstract**

This course provides basic clinical and pharmaceutical knowledge and skills for triage, diagnostics and therapy support of the most common diseases.

**Objective**

Students

- know and understand the pathomechanisms and clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed below.
- can use this knowledge to triage patients: i.e. analyse simple symptoms and diseases, make a tentative diagnosis and recommend suitable medication or further examinations or measures.

**Content**

"Pharmaceutical Care" und "Health Care";

Häufigste Erkrankungen und Therapien der
- Allergologie
- Angiologie und Hämatologie
- Dermatologie
- Endokrinologie und Diabetologie
- Gastroenterologie
- Infektiologie
- Kardiologie
- Neurologie
- Ophthalmologie
- Otorhinolaryngologie
- Pneumologie
- Psychiatrie
- Rheumatologie
- Urologie

Grundlagen der Chiropraktischen Medizin und Physiotherapie.
The performance assessments take place on: 20.12.2022 (approx. 11-13h) und 21.12.2022 (approx. 14-16h)

Please note that the assessment of this course must be passed (not compensable).

The performance assessment of the course takes place in two written on campus online partial examinations. The overall grade results from the average of the grades of both partial examinations. If the overall grade is unsatisfactory, both partial examinations must be repeated.

The courses Pharmacology and Toxicology I and II and Pathobiology provide indispensable basics which students must master at the beginning of the semester in order to successfully complete the course.

Pharmacology and Toxicology III must be visited at the same time.

### Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0423-00L</td>
<td>Drug Delivery and Drug Targeting</td>
<td>W</td>
<td>2</td>
<td>1.5V</td>
<td>J.-C. Leroux</td>
</tr>
<tr>
<td>Abstract</td>
<td>The students gain an overview on current principles, methodologies and systems for controlled delivery and targeting of drugs. This enables the students to understand and evaluate the field in terms of scientific criteria.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The focus of the course lies on developing a capacity to understand the involved technologies and methods, as well as an appreciation of the chances and constraints of their therapeutic usage, with prime attention on anticancer drugs, therapeutic peptides, proteins, nucleic acids and vaccines.</td>
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</tr>
<tr>
<td>Content</td>
<td>The course covers the following topics: drug targeting and delivery principles, macromolecular drug carriers, liposomes, micelles, micro/nanoparticles, gels and implants, administration of vaccines, targeting at the gastrointestinal level, synthetic carriers for nucleic acid drugs, ophthalmic devices, novel trends in transdermal and nasal drug delivery and 3D printing of drug delivery systems.</td>
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<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Selected lecture notes, documents and supporting material will be directly provided or may be downloaded from the course website.</td>
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</table>

Further references will be provided in the course.

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### 535-0250-00L: Biotransformation of Drugs and Xenobiotics

<table>
<thead>
<tr>
<th>Number</th>
<th>Biotransformation of Drugs and Xenobiotics</th>
<th>W</th>
<th>1</th>
<th>1V</th>
<th>S.-D. Krämer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>Goals: knowledge of the major reactions of biotransformation in drug therapy, prediction of possible metabolites of drugs and xenobiotics, recognition of structure elements and reactions which can lead to toxic metabolites. Knowledge of inter- and intraindividual factors influencing metabolism.</td>
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<tr>
<td>Content</td>
<td>Major reactions of biotransformation. Major enzymes and reaction partners involved in the biotransformation of drugs and xenobiotics. Toxic reactions of metabolites. Factors which affect the biotransformation.</td>
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</tbody>
</table>

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### 535-0546-00L: Patents

<table>
<thead>
<tr>
<th>Number</th>
<th>Patents</th>
<th>W</th>
<th>1</th>
<th>1V</th>
<th>A. Koepf, P. Pliska</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Knowledge in the field of intellectual property, especially of patents and trademarks, with particular emphasis on pharmaceutics. Introduction into industrial property; prosecution of patent applications; patent information; exploitation and enforcement of patents; peculiarities in pharmaceutics and medicine; social, political and ethical aspects; Trademarks.</td>
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<tr>
<td>Objective</td>
<td>Basic knowledge in the field of industrial property, especially of patents and trademarks, with particular emphasis on the chemical, pharmaceutical and biotech field.</td>
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<tr>
<td>Content</td>
<td>1. Introduction into industrial property (patents, trademarks, industrial designs); 2. Prosecution of patent applications (patentability); 3. Patent information (patent publications, databases, searches); 4. Exploitation and enforcement of patents (possibilities of exploitation, licenses, parallel imports, scope of protection, patent infringement); 5. Peculiarities in pharmaceutics and medicine (supplementary protection certificates, experimental use exemption, therapy and diagnosis, medical indication); 6. Social, political and ethical aspects (patents and prices for medicinal products, traditional knowledge and ethnomedicine, bioprospecting and biopiracy, human DNA inventions); 7. Trademarks, types of trademarks, grounds for refusal, peculiarities of pharma-trademarks.</td>
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</tbody>
</table>
After attending the lecture, the students are able to name significant events in the development of the pharmacy profession, pharmacy and medicines and to place them in a temporal context. They can list sources for working on questions from the history of pharmacy and evaluate their advantages and disadvantages. This enables them to confidently describe the importance of pharmacy as an independent, supporting pillar of the health system, the history of which has many interfaces with medicine, science, social and cultural history.

In the lecture, basic knowledge of the history of pharmacy is imparted, taking into account the various historical epochs. An interest in the history of pharmacy, the pharmacy profession, and medicines is an asset.

From Ethnopharmacy to Molecular Pharmacognosy

Basic understanding and awareness of ethnopharmaceutical and ethnopharmacological issues and research. Knowledge of methods used in drug discovery from natural sources. Discussion of the issues around law and international treaties. Importance of ethnopharmaceutical knowledge for world health.

Introduction into ethnopharmacy and related disciplines; definitions of terms, working methods, research projects, bioprospecting. Traditional medicinal plants of different cultures and their role in modern Western medicine (rational application of traditional uses). Historical data as sources for drug research. Today's "fashion plants." Empirical, traditional knowledge versus Evidence Based Medicine. The role of biodiversity (CBD, Rio 1992; Nagoya, 2010) and problems associated with drug discovery from natural products. Screening strategies for drug discovery (random screening versus screening based on cultural, ecological, ethnopharmacological, chemotaxonomic criteria). Traditional knowledge in relation to the fight against malaria and its implementation in research, product development and development cooperation. Introduction to and selected examples of herbal drugs and poisons, mode of action, and their ethnopharmacological importance. Critical analysis of bioprospecting as a drug discovery strategy.

Handouts will be provided.

Prerequisites: Basic lectures in biology or biochemistry and pharmaceutical biology have been attended; not suitable for first semester students.

Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>To develop a critical understanding of the relevance and limitations of the current approaches to explaining and anticipating drug effects.</td>
<td></td>
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</tbody>
</table>
| In December 2006, Pfizer stopped a large phase III study on the use of Torcetrapib for the prevention of atherosclerosis and cardiovascular disease. 800 million $ in development costs and 21 billion $ in stocks were annihilated overnight. The failure of Torcetrapib has pinpointed the limitations of an extremely reductionist view of atherosclerosis and its prevention by drug therapy. It has also highlighted what high expectations we have in a safe and wide applicability of drugs and of their economical success. Torcetrapib is not a single case. In the last 10 years, on average one drug per year was withdrawn from the market due to lack of efficacy, unexpected side effects or toxicity. This clearly shows that the common investigations and the modern understanding of drug actions are often not sufficient to predict the effects a drug will have in large patient populations. These are the topics of the present course. Using three particularly informative examples of drug failures, the problems encountered and the concepts and informative value of preclinical and clinical studies will be analyzed and discussed. Furthermore, the ethical, societal, economical and political expectations in new drugs shall be reflected.

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Prerequisites / notice</th>
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</thead>
<tbody>
<tr>
<td>Lecture slides and literature for reading and discussions will be available online.</td>
<td>Requirements: basic knowledge in Medicinal Chemistry and Pharmacology. Ability to read and understand scientific publications written in English.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>535-0310-00L</th>
<th>Glycobiology in Drug Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Protein-based drugs constitute around 25% of new approvals and most of them are glycoproteins. Using selected examples of prominent glycoprotein drugs, the course aims at providing insight into glycosylation-activity relationships and into biotechnological production and analytics.</td>
</tr>
</tbody>
</table>
| Objective | Students gain basic knowledge in "pharmaceutical glycobiology". This implies knowing and understanding:
- major mechanisms underlying the roles of glycosylation for the biological/therapeutic actions of glycoproteins (glycosylation-function relationships) using prominent examples of glycoprotein drugs,
- the major types of protein-linked glycans and the biosynthetic pathways for their formation,
- how glycoprotein drugs are produced (including the most important expression systems used), glycoengineered and analysed (quality control),
Students are able to apply this knowledge in solving simple problems in glycoprotein drug development (on paper), Students gain the ability to reflect on roles of glycosylation in various biological contexts. |
| Content | lecture plan:
1. Glycans - information carriers in biology and pharmacotherapy
2. Glucocerebrosidase and the biosynthesis of N-glycans
3. Improving the therapeutic profile of monoclonal antibodies by glycoengineering
4. Mucin-type O-glycans and sialylation as gCQA of glycoprotein hormone drugs
5. production and gCQA analysis of Glucocerebrosidase, monoclonal antibodies, glycoprotein hormone drugs - Glycoanalytics
6. EPO "the same but different"

- recent publications as cited/proposed on the lecture slides |
| Prerequisites / notice | Requirements: Basic knowledge in immunology, molecular biology, protein and carbohydrate chemistry, analytical techniques. Basic knowledge in pharmacology. |
| Fostered competencies | Subject-specific Competencies Concepts and Theories assessed Techniques and Technologies assessed |
| Method-specific Competencies Analytical Competencies assessed Problem-solving assessed |
| Social Competencies Communication assessed Self-presentation and Social Influence assessed |
| Personal Competencies Adaptability assessed Flexibility assessed Critical Thinking assessed |
| 535-0021-00L | Vitamins in Health and Disease |
| Abstract | Vitamins are essential organic compounds that cannot be synthesized by an organism and hence, they have to be acquired from the diet. This lecture will give an overview about the application of vitamins in health and disease. |
| Objective | The aim of this lecture is a critical examination of the students with the topic of "Vitamins in Health and Disease". The students will get an overview of vitamins, of their medical applications and the role of the pharmacist with "over-the-counter" products. |
| Literature | The slides used for the lectures will be provided online |
| Prerequisites / notice | Requirements: Basic knowledge in pharmaceutical glycobiology. |

| Fostered competencies | Subject-specific Competencies Concepts and Theories assessed Techniques and Technologies assessed Method-specific Competencies Analytical Competencies assessed Problem-solving assessed Social Competencies Communication assessed Personal Competencies Critical Thinking assessed |
Deficiencies of particular vitamins result in specific diseases such as for example scurvy (vitamin C deficiency). Such disease patterns are usually easily recognized and facile to be treated. The clinical utility of supplementation concerns people with severe deficiencies and a risk of complications. Latent vitamin deficiencies might result in variable disorders and risks. As an example neurological disorders in elderly as a consequence of chronic lack of vitamin B12 should be mentioned. Subclinical deficiencies are often difficult to assess. However, these are exactly the cases where advice of a pharmacist is requested.

A large intake of vitamins by over-supplementation or food fortification might be dangerous (hypervitaminosis). This is in particular the case for fat-soluble vitamins or in the case of constant intake of high amounts of water-soluble vitamins over a long time period.

The lecture 'Vitamins in Health and Disease’ will give an overview over the history and applications of vitamins and their functions to preserve good health. The utility of vitamin supplementation during conditions of deficiencies, potential consequences of a latent deficiency as well as risks of over-supplementation will be discussed.

Hand-outs will be distributed during the lecture (partly in English, partly in German).

**Book recommendation: reference books:**

- Handbuch Nährstoffe, Burgerstein, Trias Verlag ISBN 978-3-8304-6071-8

**Literature**


**Prerequisites**

Requirements: Basic knowledge in biochemistry and pharmacology. Ability to read and understand scientific publications in English.

<table>
<thead>
<tr>
<th>535-0360-00L</th>
<th>Evidence Based Phytotherapy</th>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>K. Berger Büter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Based on epidemiology, economic importance and evidence-based medicine, basic principles of rational phytotherapy will be discussed: a) Identification of drug candidates, b) registration requirements, c) criteria to assess efficacy, d) biomarkers and pharmacokinetics, e) safety and f) principles of extract generation. Important prototypes will be discussed.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Students should learn the importance of rational (= evidence-based) pharmacotherapy with herbal extracts. They should know the most important aspects of herbal medicinal products: o How are interesting development candidates identified. What are the strategies? o What are the regulatory requirements (Traditional use, well-established use, new herbal entities)? o Efficacy determination (animal/human studies, biomarkers) o Pharmacokinetics o Safety (toxicity, adverse effects, interactions) o Pharmaceutical quality o Origin of the plant raw material (wild collections, cultivation) o Ensuring consistent quality o Which extraction methods?</td>
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<tr>
<td><strong>Content</strong></td>
<td>The following important plants and products will be presented and critically discussed as examples (see program below) 1) 21.09.2: Introduction: Quality of medicinal plant, finished products, monographs (Commission E, ESCOP, HMPC), differences in terms of registration status and requirements: traditional use, well established use and new herbal entities; extracts, quality medicinal drugs. 2) 28.9.2022: Phases of clinical development, basic concepts of evidence-based medicine. Hypericum perforatum 3) 05.10.2022 - no face-to-face lecture (lecture will be pre-recorded) Silybum marianum; Pelargonium spp. 4) 12.10.2022 Phytotherapy for functional intestinal disorders; Harpagophytyum spp. 5) 19.10.2022: Lavandula oleum; Echinacea spp. 6) 26.10.2022: Cimicifuga racemosa; Cannabis sativa 7) 02.11.2022: Exam (Multiple Choice). The selection of plants may be subject to change.</td>
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<table>
<thead>
<tr>
<th>535-0022-00L</th>
<th>Computer-Assisted Drug Design</th>
<th>W</th>
<th>1 credit</th>
<th>1V</th>
<th>S. Riniker, G. Landrum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>The lecture series provides an introduction to computer applications in medicinal chemistry. The topics cover molecular representations and similarity, ligand-based virtual screening, and structure-based virtual screening. All theoretical concepts and algorithms presented are illustrated by practical applications and case studies.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The students will learn how molecules can be represented in computers and how molecular similarity is calculated. They will learn the concepts of ligand-based and structure-based virtual screening to identify potential drug candidates, and understand possibilities and limitations of computer-assisted drug design in pharmaceutical chemistry. As a result, they are prepared for professional assessment of computer-assisted drug design studies in medicinal chemistry projects.</td>
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<tr>
<td><strong>Content</strong></td>
<td>The topics include molecular representations and similarity, ligand-based virtual screening (similarity search, QSAR, etc.) and structure-based virtual screening ( docking, physics-based models).</td>
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Methods in Drug Design  ■  535-0024-00L  W  1 credit  1V  G. Schneider

Does not take place this semester.

Complementary to the practical course "Computer-Assisted Drug Design (Practical Course)" 535-0023-00L.

Compulsory for the students of the practical course, open for other interested students.

Abstract
The lecture is organized as a two-week block during the practical course "Computer-Assisted Drug Design" (535-0023-00 P), totalling 10 two-hour lectures. It provides an introduction to advanced drug design techniques and approaches emphasizing computer-assisted molecular design.

Objective
Participants will learn about computational algorithms and advanced experimental approaches to drug discovery and design, including selected actual topics and practical applications. The contents of the lecture will allow for a deeper understanding of modern computer-assisted drug design methods and how they are linked to experimental applications. The main focus is on computational medicinal chemistry, so that participants will be able to use relevant computer-based methods in own research projects.

Literature

Additional selected literature will be provided during the lecture.

Prerequisites / notice
The lecture is mandatory for all participants of the course "Computer-Assisted Drug Design" (535-0023-00 P).

Computer-Assisted Drug Design (Practical Course)  ■  535-0023-00L  W  4 credits  6P  G. Schneider

Does not take place this semester.

Limited number of participants.

Abstract
The practical course is open for master and graduate students to get an introduction into hands-on computer-assisted drug design. The class includes an introduction to computer-based screening of a virtual compound library, subsequent synthesis of candidate ligands, and biochemically testing for activity on pharmacologically important drug targets.

Objective
Participants become familiar with state-of-the-art methodologies in a real-life computer-aided medicinal chemistry project. Participants work as small teams, perform literature research and discuss recent research findings. A seminar talk is to be given presenting the molecular design strategy chosen and the results obtained during the course.

Content
The course offers the possibility for people with and without computational and or laboratory background to get an introduction into computer-assisted drug design, as well as practical training in a modern chemical laboratory. Using various software suites, the participants will computationally create and screen a virtual compound library for potential active small molecules. The process will involve an introduction to screening a virtual compound library, synthesizing candidate inhibitors, and biophysical testing against a pharmacologically important drug target.

Lecture notes
Detailed information will be handed out during the course.

Literature
Textbook:

Prerequisites / notice
The class is organized as a two-week block course.

Kick-off meeting and confirmation of registration (Vorbesprechung und Platzvergabe): During the last lecture of the class "Computer-Assisted Drug Design" (535-0022-00)

Ideally, students interested in the course participated and successfully passed the lecture "Computer-Assisted Drug Design" (535-0022-00).

Practical Pharmacy I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course provides basic knowledge relevant to pharmacy and its application in nephrology, phytotherapy, complementary medicine, wound care and pharmaceutical care. (for detailed learning objectives see the guidelines)</td>
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<tr>
<td>Objective</td>
<td>Students know and understand the therapeutic concepts of the mentioned topics and their application in practice.</td>
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<tr>
<td>Content</td>
<td>complementary medicine</td>
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<td></td>
<td>phytotherapy</td>
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<td></td>
<td>wound care</td>
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<tr>
<td></td>
<td>pharmaceutical care 2</td>
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<tr>
<td></td>
<td>nephrology</td>
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<tr>
<td>Lecture notes</td>
<td>Provided via myStudies.</td>
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<tr>
<td>Literature</td>
<td>As specified in the lecture notes</td>
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</table>

| Abstract     | This course provides basic clinical and pharmaceutical knowledge and its application for triage, diagnostics and therapy support for the most common diseases in geriatrics, women's health, oncology, paediatrics and neurology (epilepsy). In addition, the role of nutrition in special life situations and in selected health disorders is taught. |
| Objective    | - know and understand the pathomechanisms and the clinical lead and warning symptoms (red flags) of the most common diseases in the fields listed. |
|              | - can triage patients by applying this knowledge: i.e. analyse simple symptoms and disease patterns, make a tentative diagnosis and recommend suitable medication or further examinations or measures. |
|              | - know the therapeutic guidelines, drug classes and selected, practice-relevant drugs (including indications and the most frequent and important dosages, adverse drug reactions, interactions and contraindications). (for detailed learning objectives, see the guideline) |
Practical Pharmacy II

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-5502-00L</td>
<td>Pharmaceutical Manufacturing in Small Quantities</td>
<td>O</td>
<td>3</td>
<td>5G</td>
<td>P. G. Tiefenböck, A. Romagna</td>
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<td></td>
<td>(Compounding)</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Pharmaceutical Manufacturing relevant for the community pharmacy considering the &quot;GMP-Regeln in kleinen Mengen&quot; of the Pharmacopoeia: The preparation of extemporaneous products covering the most common forms under consideration of their Risks and Quality Assurance.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td>The students are able to produce pharmaceutical relevant drug Systems without further assistance, lege artis, applying the right techniques and material. The production and packaging has to follow GMP rules and tailored for the patients need. The quality control and correct documentation have to be followed. The students know the most relevant specifications, concentration and dosing ranges of common APIs and excipients. The students are familiar with the relevant literature (Pharmaceutical and legal basis) regarding the Pharmaceutical manufacturing relevant for the community pharmacies</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>Vermittlung der wichtigsten Kenntnisse, Arbeitsschritte und -techniken im Bereich der Arzneimittelherstellung in kleinen Mengen (Formula) mit Fokus auf der Herstellung, Qualitätssicherung und Risikobeurteilung einschliesslich der patientenspezifischen Abgabenpraxis.</td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td></td>
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<td></td>
<td>Safety concept: <a href="https://chab.ethz.ch/studium/bachelor1.html">https://chab.ethz.ch/studium/bachelor1.html</a></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-5503-00L</td>
<td>Institutional Pharmacy</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>P. Wiedemeier, M. Lutters, E. Martinelli, I. S. Vogel Kahmann</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td>Organisation of institutional environments (emergency hospitals), with special focus on the medication process and institutional pharmaceutical care (continuum of care).</td>
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<td>Objective</td>
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<td>Students understand the concept of continuum of care and its practical implementation. They know the medication process within an institutional environment. They are able to find the necessary information and deal with problems in connection with pharmaceuticals, to evaluate them and to communicate and document their findings adequately. They know how a hospital is organised (procedures, possible problems), responsibilities of the different members of the staff and, most importantly, what the function of a hospital pharmacy is.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
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<td></td>
<td>Principals of the organisation of institutional environments (emergency hospitals), with special focus on medication processes and institutional pharmaceutical care (circulation of medication, continuum of care). Hygiene regulations, medical products, applications, drug formularies, patient files, SOAP notes, kardex study. Participation at interdisciplinary visits, internal trainings and doctors' reports as well as visitation of the emergency room. Drug interaction, generic substitution, quality management and pharmacovigilance.</td>
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<tr>
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<td>Prerequisites / notice</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>535-5524-00L</td>
<td>Clinical Trainings</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>A. Gutzeit, D. Stämpfli, P. Wiedemeier</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
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<td></td>
<td>Basic training on and around patients with practical confrontation. The path of acute patients from patient presentation, through triage and diagnostics to therapy.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>Students will be able to understand the medical-clinical way of thinking for the diagnosis and treatment of acute patients. They complete the change of perspective from the molecular mechanism of action of drugs to the treatment of patients in all its complexity. Using real patient examples, students acquire exemplary knowledge in diagnostics and triage as well as therapy selection and therapy support. They consolidate their understanding of the importance of pharmaceutical care before and after hospitalization.</td>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-5526-00L</td>
<td>Injection Techniques and Vaccinations</td>
<td>O</td>
<td>2</td>
<td>3G</td>
<td>I. S. Vogel Kahmann, C. Halin Winter</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Die Studierenden lehren die praktische Durchführung von subkutanen (s.c.) und intramuskulären (i.m.) Injektionen. Sie wissen, wie in Notfallsituationen vorzugehen ist.Die Besonderheiten von häufig eingesetzten parenteral zu verabreichenden Medikamenten, insbesondere von Impfungen, sind bekannt.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td></td>
<td>Die Studierenden erwerben das theoretische Wissen und die praktischen Fähigkeiten, welche für die s.c. und i.m. Verabreichung von Medikamenten erforderlich sind. Sie sind fähig, Risikopatienten zu identifizieren und sind geschult, bei Notfällen (z.B. Anaphylaxie) korrekt zu handeln.Die Studierenden kennen die in der Schweiz zur Verfügung stehenden Impfungen, den schweizerischen Impfplan und sind vertraut mit der Anwendung von elektronischen Hilfsmitteln bei Fragestellungen rund um das Impfen.Die Studierenden kennen die rechtlichen Grundlagen und regulatorischen Aspekte bezüglich Impfen in der Apotheke. Die Studierenden kennen verschiedene Verbandsmaterialien und können diese anwenden, um akute Wunden zu versorgen.</td>
</tr>
</tbody>
</table>

Lecturer notes

| Literature | Wird auf mystudies veröffentlicht. |


Schutzkonzept: https://chab.ethz.ch/studium/bachelor1.html

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1855 of 2416
### Compensatory Courses

The elective courses can be used as compensatory courses.

### Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-CHAB

see Science in Perspective: Language Courses ETH/UZH

### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0660-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>40D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their master thesis:

- a. successful completion of the bachelor programme;
- b. fulfilling of any additional requirements necessary to gain admission to the master programme.

Abstract

During the Master's thesis students prove their ability to independent, structured scientific work. The Master's thesis is usually carried out in a subject area of Pharmaceutical Sciences as chosen by the student.

Objective

In the Master Thesis students prove their ability to independent, structured and scientific working.

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0135-AAL</td>
<td>Clinical Chemistry I</td>
<td>E-</td>
<td>1 credit</td>
<td>2R</td>
<td>M. Hersberger</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Introduction into fundamentals of laboratory diagnostics and overview of the laboratory parameters concerning inflammation, lipid metabolism, myocardial infarction, diabetes, kidney function, urinary diagnostics, liver function, blood coagulation, blood count, therapeutic drug monitoring and drugs of abuse screening.

Objective

Overview of the possibilities and limitations in clinical laboratory diagnostics. Indications and methods of everyday parameters are known.

Content

Introduction into medical laboratory diagnostics: immunochemical methods, diagnostics of inflammation, acute myocardial infarction, lipid metabolism, diabetes, kidney function and urinary diagnostics, blood coagulation, blood count, therapeutic drug monitoring, drugs of abuse screening, common diagnostics of liver diseases, point-of-care diagnostics.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>535-0440-AAL</td>
<td>Quality Management in Pharmaceutical Business</td>
<td>E-</td>
<td>1 credit</td>
<td>2R</td>
<td>A. Sterchi</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

The students know the relevance and the role of quality assurance measures to assure quality, efficacy and safety of drugs. The students know the most important Swiss regulations, including the associated European regulations, which are relevant from a quality assurance point of view and they are able to interpret the content of this regulations.

Objective

The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content

From "Statistics for research" (online)
- Ch 1: The Role of Statistics
- Ch 2: Populations, Samples, and Probability Distributions
- Ch 3: Binomial Distributions
- Ch 6: Sampling Distribution of Averages
- Ch 7: Normal Distributions
- Ch 8: Student's t Distribution
- Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
- Ch 1: Basics
- Ch 2: The R Environment
- Ch 3: Probability and distributions
- Ch 4: Descriptive statistics and tables
- Ch 5: One- and two-sample tests
- Ch 6: Regression and correlation
Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435
  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
</tbody>
</table>

Method-specific Competencies

<table>
<thead>
<tr>
<th>Analytical Competencies</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media and Digital Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
</tbody>
</table>

Personal Competencies

| Self-direction and Self-management | assessed |

Pharmacy Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>W+</th>
<th>W</th>
<th>E-</th>
<th>Z</th>
<th>Dr</th>
<th>ECTCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
<td>Eligible for credits and recommended</td>
<td>Eligible for credits</td>
<td>Recommended, not eligible for credits</td>
<td>Courses outside the curriculum</td>
<td>Suitable for doctorate</td>
<td>European Credit Transfer and Accumulation System</td>
</tr>
</tbody>
</table>

Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>G</th>
<th>U</th>
<th>S</th>
<th>K</th>
<th>P</th>
<th>A</th>
<th>D</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>lecture</td>
<td>lecture with exercise</td>
<td>exercise</td>
<td>seminar</td>
<td>colloquium</td>
<td>practical/laboratory course</td>
<td>independent project</td>
<td>diploma thesis</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

Special students and auditors need special permission from the lecturers.
### The Zurich Physics Colloquium

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
</tbody>
</table>

**Abstract**
Research colloquium

**Objective**
The goal of this event is to bring you closer to current day research in all fields of physics. In each semester we have a set of distinguished speakers covering the full range of topics in physics. As a participating student should learn how to follow a research talk. In particular, you should be able to extract key points from a colloquium where you don't necessarily understand every detail that is presented.

---

**Physics (General Courses) - Key for Type**

<table>
<thead>
<tr>
<th>Code</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td></td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Course outside the curriculum</td>
</tr>
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</table>

**Key for Hours**

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<tr>
<th>Code</th>
<th>Type</th>
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<tbody>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
First Year

Minor Courses

Science in Perspective

First Year Compulsory Courses

Bachelor Studies (Programme Regulations 2021)

First Year Compulsory Courses

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1261-07L</td>
<td>Analysis I: One Variable</td>
<td>O</td>
<td>10 credits</td>
<td>6V+3U</td>
<td>G. Felder</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the differential and integral calculus in one real variable: fundamentals of mathematical thinking, numbers, sequences, basic point set topology, continuity, differentiable functions, ordinary differential equations, Riemann integration.

Objective
The ability to work with the basics of calculus in a mathematically rigorous way.

Literature
H. Amann, J. Escher: Analysis I
https://link.springer.com/book/10.1007/978-3-7643-7756-4

J. Appell: Analysis in Beispielen und Gegenbeispielen

R. Courant: Vorlesungen über Differential- und Integralrechnung

O. Forster: Analysis 1

H. Heuser: Lehrbuch der Analysis

K. Königsberger: Analysis 1
https://link.springer.com/book/10.1007/978-3-642-18490-1

W. Walter: Analysis 1
https://link.springer.com/book/10.1007/978-3-540-35078-0

V. Zorich: Mathematical Analysis I (englisch)

A. Beutelspacher: "Das ist o.B.d.A. trivial"

H. Schichl, R. Steinbauer: Einführung in das mathematische Arbeiten

402-1701-00L | Physics I                  | O    | 7 credits  | 4V+2U | W. Wegscheider |

Abstract
This course gives a first introduction to Physics with an emphasis on classical mechanics.

Objective
Acquire knowledge of the basic principles regarding the physics of classical mechanics. Skills in solving physics problems.

252-0847-00L | Computer Science         | O    | 5 credits  | 2V+2U | C. Cotrini Jimenez, F. O. Friedrich Wicker |

Abstract
The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.

Objective
Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens "behind the scenes" when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.

Content
The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.

Lecture notes
English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.

Literature
Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010
Andrew Koenig and Barbara E. Moo: Accelerated C++, Addison-Wesley, 2000

First Year Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-1151-00L</td>
<td>Linear Algebra I</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>P. Biran, M. Einsiedler</td>
</tr>
</tbody>
</table>

Abstract

Objective
- Mastering basic concepts of Linear Algebra
- Introduction to mathematical methods
- Basics
- Vector spaces and linear maps
- Systems of linear equations and matrices
- Determinants
- Endomorphisms and eigenvalues
Lecture notes

We will provide German lecture notes and an English translation at latest at the start of the semester. Lecture notes in German and an English translation will be published on the website of the course, at latest at the start of the semester. Besides this we also recommend:


In addition we recommend this general introduction into studying mathematics:

Literature

Besides this we also recommend:


Second and Third Year Compulsory Courses

Examination Blocks

Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2303-00L</td>
<td>Complex Analysis</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>E. Kowalski</td>
</tr>
<tr>
<td>Abstract</td>
<td>Complex functions of one variable, Cauchy-Riemann equations, Cauchy theorem and integral formula, singularities, residue theorem, index of closed curves, analytic continuation, special functions, conformal mappings, Riemann mapping theorem.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Working knowledge of functions of one complex variables; in particular applications of the residue theorem.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Th. Gamelin: Complex Analysis. Springer 2001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>D. Salamon: &quot;Funktionentheorie&quot;. Birkhauser, 2011. (In German)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K.Jaenich: Funktionentheorie. Springer Verlag</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>R.Remmert: Funktionentheorie I. Springer Verlag</td>
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</table>

<table>
<thead>
<tr>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-2203-01L</td>
<td>Classical Mechanics</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>M. Gaberdiel</td>
</tr>
<tr>
<td>Abstract</td>
<td>A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Objective</td>
<td>Fundamental understanding of the description of Mechanics in the Lagrangian and Hamiltonian formulation. Detailed understanding of important applications, in particular, the Kepler problem, the physics of rigid bodies (spinning top) and of oscillatory systems.</td>
<td></td>
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</tr>
</tbody>
</table>

Examination Block IIa

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-2883-00L</td>
<td>Physics III</td>
<td>O</td>
<td>7</td>
<td>4V+2U</td>
<td>Y. Chu</td>
</tr>
<tr>
<td>Abstract</td>
<td>An introductory course on quantum and atomic physics including optics and statistical physics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>A basic introduction to quantum and atomic physics, including basics of optics and equilibrium statistical physics. The course will focus on the relation of these topics to experimental methods and observations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>License notes</td>
<td>Im Rahmen der Veranstaltung werden die Folien in elektronischer Form zur Verfügung gestellt. Ergänzendes Buch wird als Pflichtlektüre empfohlen. Es wird kein Skript in der Vorlesung verteilt. Wir werden die Quantenmechanik anhand der Schrödinger-Gleichung mit den klassischen elektro-magnetischen Wellen vergleichen. Zu den klassischen Wellen werden Ergänzungsunterlagen verteilt.</td>
<td></td>
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</tr>
</tbody>
</table>

Examination Block IIIa

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2333-00L</td>
<td>Mathematical Methods of Physics I</td>
<td>O</td>
<td>6</td>
<td>3V+2U</td>
<td>T. H. Willwacher</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introductory course on quantum and atomic physics including optics and statistical physics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Abstract

Examination Block IIb
Offered in the Spring Semester

Other Compulsory Courses
no course offering in this semester

Bachelor Studies (Programme Regulations 2016)

Second and Third Year Compulsory Courses

Examination Block I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>401-2303-00L</td>
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<td>O</td>
<td>6 credits</td>
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<td>E. Kowalski</td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

401-2333-00L | Mathematical Methods of Physics I | O    | 6 credits | 3V+2U | T. H. Willwacher |

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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</table>

Examination Block II

<table>
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<tr>
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</tr>
</tbody>
</table>

Examination Block III

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1861 of 2416
Quantum Mechanics I

Abstract

Applications: simple potentials in wave mechanics, scattering and resonance, harmonic oscillator, hydrogen atom, and perturbation theory.

Objective
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

Content
The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.

Lecture notes
Auf Moodle

Literature
G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L. I. Schiff, Quantum Mechanics
R. Feynman and A. R. Hibbs, Quantum Mechanics and Path Integrals
J. J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics

Fostered competencies
Subject-specific Competencies
Concepts and Theories: assessed
Techniques and Theories: not assessed

Method-specific Competencies
Analytical Competencies: assessed
Decision-making: not assessed
Media and Digital Technologies: not assessed
Problem-solving: assessed
Project Management: not assessed

Social Competencies
Communication: not assessed
Cooperation and Teamwork: not assessed
Leadership and Responsibility: not assessed
Self-presentation and Social Influence: not assessed
Sensitivity to Diversity: not assessed
Negotiation: not assessed

Personal Competencies
Adaptability and Flexibility: not assessed
Creative Thinking: assessed
Critical Thinking: not assessed
Creativity and Work Ethics: not assessed
Integrity and Work Ethics: not assessed
Self-awareness and Self-reflection: not assessed
Self-direction and Self-management: not assessed

Core Courses

Core Courses in Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0263-00L</td>
<td>Astrophysics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>S. Lilly</td>
</tr>
</tbody>
</table>

Abstract
This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.

Objective
The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.

Lecture notes
A comprehensive "script" (240 pages, with detailed derivations) is provided to students. In addition, all powerpoint slides shown in the lectures are provided.

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0255-00L</td>
<td>Introduction to Solid State Physics</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>C. Degen</td>
</tr>
</tbody>
</table>

Abstract
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.

Objective
Introduction to Solid State Physics.

Content
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism, superconductivity.

Lecture notes
The script will be available on moodle.

Literature
Ibach & Lüth, Festkörperphysik
C. Kittel, Festkörperphysik
Ashcroft & Mermin, Festkörperphysik
W. Känzig, Kondensierte Materie

Prerequisites / notice
Voraussetzungen: Physik I, II, III wünschenswert

Practical Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0000-01L</td>
<td>Physics Lab 1</td>
<td>O</td>
<td>5</td>
<td>4P</td>
<td>A. Eichler, M. Kroner, A. Eggenberger</td>
</tr>
</tbody>
</table>

Only students from 3rd Semester BSc Physics on are admitted to Physics Lab 2.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1862 of 2416
The goals of the proseminar are four-fold:

- Why does one conduct experiments, and how should an experiment be planned?
- How does one set up an experiment? What are the important characteristics of measurement instruments and methods?
- Introduction to basic statistical data analysis
- Critical interpretation of measurement results
- Scientific communication, reporting, graphic representation of results
- Ethical aspects of experimental research and reporting

Experiments with examples from mechanics, optics, thermodynamics, electricity and radiation.

Anleitung zum Physikalischen Praktikum; Vorlesungszusammenfassung

9 Experiments have to be conducted (typically in teams of 2).

In the first week, only an introductory event is taking place in the lecture hall. This event provides relevant information regarding safety and organisational matters (e.g. testat conditions).

Students must pass an online safety test to be allowed to conduct experiments in the lab. It is recommended that every student acquires an individually adjusted safety goggle

**Proseminars, Experimental and Theoretical Semester Papers**

To organise a semester project take contact with one of the instructors.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0210-BSL</td>
<td><strong>Proseminar Theoretical Physics</strong></td>
<td>W</td>
<td>8 credits</td>
<td>4S</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>A guided self-study of original papers and of advanced textbooks in theoretical physics. Within the general topic, determined each semester, participants give a presentation on a particular subject and deliver a written report.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The goals of the proseminar are four-fold: i) to expand your knowledge of theoretical physics; ii) to learn how to give a professional presentation; iii) to learn how to write a scientific report; and iv) to take part in scientific discussions.</td>
<td></td>
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</tr>
</tbody>
</table>

| 402-0217-BSL | **Semester Project in Theoretical Physics** | W    | 8 credits | 15A   | Supervisors       |
| Abstract | This course unit is an alternative if no suitable "Proseminar Theoretical Physics" is available or if the proseminar is already overbooked. The goals of the proseminar are four-fold: i) to expand your knowledge of theoretical physics; ii) to learn how to give a professional presentation; iii) to learn how to write a scientific report; and iv) to take part in scientific discussions. |      |       |       |                   |
| Objective | The goals of the proseminar are four-fold: i) to expand your knowledge of theoretical physics; ii) to learn how to give a professional presentation; iii) to learn how to write a scientific report; and iv) to take part in scientific discussions. |      |       |       |                   |

| 402-0215-BSL | **Experimental Semester Project in Physics** | W    | 8 credits | 15A   | Supervisors       |
| Abstract | The aim of the project is to give the student experience in working in a research environment, carrying out physics experiments, analysing and interpreting the resulting data. |      |       |       |                   |
Objective
- conduct a project in a research laboratory,
- discuss their experimental results and conclusions in a team,
- present their experimental findings in written and oral form.

Prerequisites / notice
Die Leistungskontrolle erfolgt aufgrund eines oder mehrerer schriftlicher Berichte bzw. einer schriftlichen Arbeit.

402-0719-BSL
Abstract
Particle Physics at PSI (Paul Scherrer Institute)  
During semester breaks 6-12 students stay for 3 weeks at PSI and participate in a hands-on course on experimental particle physics. A small real experiment is performed in common, including apparatus design, construction, running and data analysis. The course includes some lectures, but the focus lies on the practical aspects of experimenting.

Objective
Students learn all the different steps it takes to perform a complete particle physics experiment in a small team. They acquire skills to do this themselves in the team, including design, construction, data taking and data analysis.

402-0717-BSL
Abstract
Particle Physics at CERN  
During the semester break participating students stay for 4 weeks at CERN and perform experimental work relevant to our particle physics projects. Dates to be agreed upon.

Objective
Students learn, by doing, the needed skills to perform a small particle physics experiment: setup, problem solving, data taking, analysis, interpretation and presentation in a written report of publication quality.

Content
Detailed information in: https://ethteilchenpraktikum.web.cern.ch/

Prerequisites / notice
Language of instruction: English or German

402-0340-BSL
Abstract
Medical Physics  
In agreement with the lecturers a semester paper in the context of the topics discussed in the lectures can be written.

402-0000-10L
Abstract
Physics Lab 4  
Prerequisite: "Physics Lab 3" completed. Before enrolling in "Physics Lab 4", please enrol in "Physics Lab 3".

Enrol at most once in the course of the Bachelor programme!

Objective
Students learn to independently perform advanced experiments and document them scientifically correct.

The following aspects are emphasized:
- understanding complicated physical phenomena
- structured approach to experiments with complex instruments
- various practical aspects of experimenting and determining uncertainties
- learning the relevant statistical methods for data analysis
- interpretation of measurements and uncertainties
- describing the experiments and the results in a scientifically proper manner, in direct analogy to publishing
- ethical aspects of experimental research and scientific communication

Content
We offer experiments covering the following topics:
Basic topics from mechanics, optics, thermodynamics, electromagnetism and electronics; as well as central topics from nuclear and particle physics, quantum electronics, quantum mechanics, solid state physics and astrophysics.

Lecture notes
Instructions for experiments are available in English.

Prerequisites / notice
From a variety of over 50 experiments, students have to perform 4 experiments covering different topics. The experimental work is complemented by writing a scientific report.

Fostered competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Problem-solving
- Social Competencies
  - Communication
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-direction and Self-management

Science in Perspective

Language Courses

Additional Courses, Seminars and Colloquia

First or Second Year Additional Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0351-00L</td>
<td>Astronomy</td>
<td>Z</td>
<td>2</td>
<td>2V</td>
<td>H. M. Schmid, A. M. Glauser</td>
</tr>
</tbody>
</table>

Abstract
An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology
Objective
This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.

Content
Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie.

Lecture notes
Kopien der Präsentationen werden zur Verfügung gestellt.

Literature
Der Neue Kosmos. A. Unsöld, B. Baschek, Springer

Additional Courses (from Second Year Mathematics Bachelor)

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2003-00L</td>
<td>Algebra I</td>
<td>Z</td>
<td>7 credits</td>
<td>3V+2U</td>
<td>R. Pink</td>
</tr>
</tbody>
</table>

Abstract
Introduction and development of some basic algebraic structures - groups, rings, fields.

Objective
Introduction to basic notions and results of group, ring and field theory.

Content
Group Theory: basic notions and examples of groups, subgroups, factor groups, homomorphisms, group actions, Sylow theorems, applications

Ring Theory: basic notions and examples of rings, ring homomorphisms, ideals, factor rings, euclidean rings, principal ideal domains, factorial rings, applications

Field Theory: basic notions and examples of fields, field extensions, algebraic extensions, applications

Literature
Karpfinger-Meyberg: Algebra, Spektrum Verlag
S. Bosch: Algebra, Springer Verlag
B.L. van der Waerden: Algebra I und II, Springer Verlag
S. Lang, Algebra, Springer Verlag
A. Knapp: Basic Algebra, Springer Verlag
J.F. Humphreys: A Course in Group Theory (Oxford University Press)
G. Smith and O. Tabachnikova: Topics in Group Theory (Springer-Verlag)
M. Artin: Algebra (Birkhaeuser Verlag)

Seminars and Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium

Objective
The goal of this event is to bring you closer to current day research in all fields of physics. In each semester we have a set of distinguished speakers covering the full range of topics in physics. As a participating student should learn how to follow a research talk. In particular, you should be able to extract key points from a colloquium where you don't necessarily understand every detail that is presented.

<table>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0800-00L</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>J. Renes, University lecturers</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium

Objective
The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.

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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>A. Cattaneo, G. Felder, M. Gaberdiel, G. M. Graf, P. Hintz, T. H. Willwacher</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium

<table>
<thead>
<tr>
<th>Number</th>
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Abstract
Research colloquium

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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0600-00L</td>
<td>Nuclear and Particle Physics with Applications</td>
<td>E-</td>
<td>0 credits</td>
<td>2S</td>
<td>A. Rubbia, K. S. Kirch</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0893-00L</td>
<td>Particle Physics Seminar</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>T. K. Gehrmann</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium
Occasionally, talks may be delivered in German.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0700-00L</td>
<td>Seminar in Elementary Particle Physics</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>M. Spira, University lecturers</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium
Stay informed about current research results in elementary particle physics.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0746-00L</td>
<td>Seminar: Particle and Astrophysics (Aktuelles aus der E-Teilchen- und Astrophysik)</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium
In Seminarvorträgen werden aktuelle Fragestellungen aus der Teilchenphysik vom theoretischen und experimentellen Standpunkt aus diskutiert. Besonders wichtig erscheint uns der Bezug zu den eigenen Forschungsmöglichkeiten am PSI, CERN und DESY.

<table>
<thead>
<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>402-0300-00L</td>
<td>IPA Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>A. Biland, A. de Cosa, A. Refregier, H. M. Schmid, further lecturers</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0530-00L</td>
<td>Mesoscopic Systems</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>T. M. Ihn</td>
</tr>
</tbody>
</table>

Abstract
Research colloquium
Students are able to understand modern experiments in the field of mesoscopic systems and nanostructures. They can present their own results, critically reflect published research in this field, explain both to an audience of physicists, and participate in a critical and constructive scientific discussion.

227-0980-00L Seminar on Biomedical Magnetic Resonance

Abstract
Current developments and problems of magnetic resonance imaging (MRI)

Objective
Getting insight into advanced topics in magnetic resonance imaging

227-1043-00L Neuroinformatics - Colloquia (University of Zurich)

Abstract
The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.

Objective
The goal of these talks is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.

Content
The topics depend heavily on the invited speakers, and thus change from week to week. All topics concern neural computation and their implementation in biological or artificial systems.

Recent Research Highlights in Astrophysics (University of Zurich)

Abstract
The colloquium in Neuroinformatics is a series of lectures given by invited experts. The lecture topics reflect the current themes in neurobiology and neuromorphic engineering that are relevant for our Institute.

Objective
The goal of these talks is to provide insight into recent research results. The talks are not meant for the general public, but really aimed at specialists in the field.

Content
The topics depend heavily on the invited speakers, and thus change from week to week. All topics concern neural computation and their implementation in biological or artificial systems.

➡️ Selection of Higher Semester Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>W</td>
<td>5</td>
<td>4G</td>
<td>R. Käppeli</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.</td>
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</tr>
<tr>
<td>Content</td>
<td>First semester (Astro-Particle Physics I): - definition of 'Astro-Particle Physics' - important historical experiments - chemical composition of the cosmic rays - direct observations of cosmic rays - indirect observations of cosmic rays - 'extended air showers' and 'cosmic muons' - 'knee' and 'ankle' in the energy spectrum - the 'anti-matter problem' and the Big Bang - 'cosmic accelerators' - important historical experiments - important historical experiments - important historical experiments - important historical experiments - important historical experiments - important historical experiments - important historical experiments - important historical experiments - important historical experiments - important historical experiments</td>
<td></td>
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</tr>
</tbody>
</table>

| Literature | See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/ |

| 402-0396-00L | Recent Research Highlights in Astrophysics | E- | 0 | 1S | University lecturers |
| Abstract     | No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: AST006 |
| Objective    | The goal of this course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations. |
| Content      | The topics depend heavily on the invited speakers, and thus change from week to week. All topics concern neural computation and their implementation in biological or artificial systems. |

| 402-0713-00L | Astro-Particle Physics I | W     | 6    | 2V+1U | A. Biland |
| Abstract     | This lecture gives an overview of the present research in the field of Astro-Particle Physics, including the different experimental techniques. In the first semester, main topics are the charged cosmic rays including the antimatter problem. The second semester focuses on the neutral components of the cosmic rays as well as on some aspects of Dark Matter. |
| Objective    | Successful students know: - experimental methods to measure cosmic ray particles over full energy range - current knowledge about the composition of cosmic ray - possible cosmic acceleration mechanisms - correlation between astronomical object classes and cosmic accelerators - information about our galaxy and cosmology gained from observations of cosmic ray |
| Content      | First semester (Astro-Particle Physics I): - definition of 'Astro-Particle Physics' - important historical experiments - chemical composition of the cosmic rays - direct observations of cosmic rays - indirect observations of cosmic rays - 'extended air showers' and 'cosmic muons' - 'knee' and 'ankle' in the energy spectrum - the 'anti-matter problem' and the Big Bang - 'cosmic accelerators' |

| Lecture notes | See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/ |
| Literature    | See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/ |

| 402-0737-00L | Energy and Sustainability in the 21st Century (Part I) | W | 6 | 2V+1U | P. Morf |
| Abstract     | Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts. How much energy do we need and can it be provided in a way that allows for sustainable existence? |
| Objective    | Why is energy important for life and our society? How did energy use change over time? Which effects did these changes have on the environment? What are the physical basics of energy technologies? When, why and how did technology and science of energy come together? What are the limits and benefits of all the various energy technologies? How can different energy technologies be compared? Can we understand the changes in the current energy systems? How will the energy systems of the future look like? How fast can we and should we enforce the current energy transition? Which could be the overall guide lines for a working energy system of the future? |

| Lecture notes | See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/ |
| Literature    | See lecture home page: http://ihp-lx2.ethz.ch/AstroTeilchen/ |
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
13. Economics of Energy, Learning Curves, Technology Assessments and Innovation
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Lecture notes
- The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
- Clean Disruption of Energy and Transportation, T. Seba 2014
- Renewable Energy – Without the Hot Air, D.J.C. Mackay 2009
- Energy and Civilization: A History, V. Smil, 2018

Literature
- The Theory of Quantum Information
- Nielsen and Chuang, Quantum Information and Computation
- Preskill, Lecture Notes on Quantum Computation
- Wilde, Quantum Information Theory
- Watrous, The Theory of Quantum Information

Prerequisites / notice
- Basics of Physics applied to Energy and Energy Technology.
- Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
- Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

402-0461-00L Quantum Information Theory
Abstract
The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.
Objective
By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.
Content
Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.
Literature
- Nielsen and Chuang, Quantum Information and Computation
- Wilde, Quantum Information Theory
- Preskill, Lecture Notes on Quantum Computation

402-0580-00L Superconductivity
Abstract
Superconductivity; thermodynamics, London and Pippard theory; Ginzburg-Landau theory: spontaneous symmetry breaking, flux quantization, type I and II superconductors; microscopic BCS theory: electron-phonon mechanism, Cooper pairing, quasiparticle spectrum, thermodynamics and response to magnetic fields; Josephson effect: superconducting quantum interference devices (SQUID) and other applications.
Objective
Introduction to the most important concepts of superconductivity both on phenomenological and microscopic level, including experimental and theoretical aspects.
Content
This lecture course provides an introduction to superconductivity, covering both experimental as well as theoretical aspects. The following topics are covered:
- Basic phenomena of superconductivity: thermodynamics, electrodynamic, London and Pippard theory; Ginzburg-Landau theory: spontaneous symmetry breaking, flux quantization, properties of type I and II superconductors; mixed phase; microscopic BCS theory: electron-phonon mechanism, Cooper pairing, coherent state, quasiparticle spectrum, thermodynamics and response to magnetic fields; Josephson effect, superconducting quantum interference devices (SQUID) and other applications.
Literature
- M. Tinkham "Introduction to Superconductivity"
- P. G. de Gennes "Superconductivity Of Metals And Alloys"
- A. A. Abrikosov "Fundamentals of the Theory of Metals"
- J.B. Ketterson & S.N. Song "Superconductivity"
- H. Stolz "Supraleitung" (German)
- K. Fossheim & A. Sudbo "Superconductivity: Physics and Applications"

402-0674-00L Physics in Medical Research: From Atoms to Cells
Abstract
Scanning probe and diffraction techniques allow studying activated atomic processes during early stages of epitalial growth. For quantitative description, rate equation analysis, mean-field nucleation and scaling theories are applied on systems ranging from simple metallic to complex organic materials. The knowledge is expanded to optical and electronic properties as well as to proteins and cells.
The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

High-resolution electron diffraction is complementary to scanning probe techniques and provides exact mean values. Some phenomena are quantitatively described by the kinematic theory and perfectly understood by means of the Ewald construction. Other phenomena need to be described by the more complex dynamical theory. Electron diffraction is not only associated with elastic scattering but also inelastic excitation mechanisms that reflect the electronic structure of the surfaces studied. Low-energy electrons lead to phonon and high-energy electrons to plasmon excitations. Both effects are perfectly described by dipole and impact scattering.

Thin-films of rather complex organic materials are often quantitatively characterized by photons with a broad range of wavelengths from ultra-violet to infra-red light. Asymmetries and preferential orientations of the (anisotropic) molecules are verified using the optical dichroism and second harmonic generation measurements. Recently, ellipsometry has been introduced to on-line monitor film thickness, and roughness with sub-nanometer precision. These characterisation techniques are vital for optimising the preparation of medical implants.

Cell-surface interactions are related to the cell adhesion and the contractile cellular forces. Physical means have been developed to quantify these interactions. Other physical techniques are introduced in cell biology, namely to count and sort cells, to study cell proliferation and metabolism and to determine the relation between cell morphology and function.

X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.

**Objective**

The lecture series is motivated by an overview covering the skin of the crystals, roughness analysis, contact angle measurements, protein absorption/activity and monocye behaviour.

As the first step, real structures on clean surfaces including surface reconstructions and surface relaxations, defects in crystals are presented, before the preparation of clean metallic, semiconducting, oxido and organic surfaces are introduced.

The atomic processes on surfaces are activated by the increase of the substrate temperature. They can be studied using scanning tunneling microscopy (STM) and atomic force microscopy (AFM). The combination with molecular beam epitaxy (MBE) allows determining the sizes of the critical nuclei and the other activated processes in a hierarchical fashion. The evolution of the surface morphology is characterized by the density and size distribution of the nanostructures that could be quantified by means of the rate equation analysis, the mean-field nucleation theory, as well as the scaling theory. The surface morphology is further characterized by defects and nanostructure's shapes, which are based on the strain relieving mechanisms and kinetic growth processes.

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X-rays are more and more often used to characterise the human tissues down to the nanometer level. The combination of highly intense beams only some micrometers in diameter with scanning enables spatially resolved measurements and the determination of tissue's anisotropies of biopsies.
Fundamentals of Mathematical Statistics
Basics of probability theory and the theory of stochastic processes in discrete time

Electronics for Physicists I (Analogue)
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology.
Practical exercises in small groups to the above themes complement the lectures.

Recommended references include the following:


Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and $L^p$ spaces).

401-3601-00L Probability Theory
At most one of the three course units (Bachelor Core Courses)
401-3641-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

Abstract
Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles; Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed range theorem; spectral theory of self-adjoint operators in Hilbert spaces.

Objective
Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature
Recommended references include the following:


Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and $L^p$ spaces).

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Objective
Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature
Recommended references include the following:


Abstract
Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists.

Objective
The "IT at D-PHYS" introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.

The "IT and Information Security" crash course will address the most common threats you'll encounter when using the internet and teach you how to fend them off.

The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges.

Use the dedicated web page https://www.lehrbetrieb.ethz.ch/laborpraktika to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to https://compenv.phys.ethz.ch for the detailed contents.

Content
Introduction:
IT at D-PHYS (IT service providers and IT services at D-PHYS)
IT and Information Security

Modules:

- Linux Basics I (system components, basic shell usage)
- Linux Basics II (advanced tools, scripting)
- Python Ecosystem I (interpreters, packages, virtual environments)
- Python Ecosystem II (development environments, formatter and linter, string formatting, regexp)
- System Aspects (how the hardware affects your scientific code and vice versa)

Physics Bachelor - Key for Type

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<th>W</th>
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Key for Hours

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<td>exercise</td>
<td>seminar</td>
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</table>

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Human Learning (EW1)

This lecture is only apt for students who intend to enrol in the programs “Teaching Diploma” or “Teaching Certificate”. It is about learning in childhood and adolescence.

Abstract

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content

Thematic Schwerpunkte:

- Lernen als Verhaltensänderung und als Informationsverarbeitung: Das menschliche Gedächtnis unter besonderer Berücksichtigung der Verarbeitung symbolischer Information; Lernen als Wissenskonstruktion und Kompetenzerwerb unter besonderer Berücksichtigung des Wissenstransfers; Lernen durch Instruktion und Erklärungen; Die Rolle von Emotion und Motivation beim Lernen; Interindividuelle Unterschiede in der Lernfähigkeit und ihre Ursachen; Intelligenztheorien, Geschlechtsunterschiede beim Lernen

Lernformen:


Coping with Psychosocial Demands of Teaching (EW4 W 2V)

Number of participants limited to 20.

Abstract

In this class, students will learn concepts and skills for coping with psychosocial demands of teaching.

Objective

(1) They know relevant rules of conversation and conflict management and are able to apply them in an appropriate way in the school context (e.g. in parental talks).
(2) They know core aspects of classroom management and know how to apply it concretely (e.g. promoting a positive learning atmosphere, avoiding disciplinary difficulties) and they are aware of possible contacts (e.g. illegal or psychological services).

Cognitively Activating Instructions in MINT Subjects (EW2 2S)

This course unit can only be enrolled after successful participation in, or during enrollment in the course “Human Learning (EW 1)”. It is recommended, but not a mandatory prerequisite.

Abstract

This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective

- Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice

Für eine reibungslose Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.
In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

Objective
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

Content
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys in mathematics? Do girls perform better in language in STEM contexts? Are there gender differences relevant to education and STEM learning that have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Pre-requisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

851-0228-00L Gender Issues In Education and STEM

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Abstract
In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.

Objective
- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

Content
Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys in mathematics? Do girls perform better in language in STEM contexts? Are there gender differences relevant to education and STEM learning that have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.

The seminar builds on the active participation of students in reading, presenting and critically discussing selected papers in the field. We focus on empirical research and integrate implications for the classroom context. In a final small-group assignment, students integrate and elaborate on the topics learned in the seminar.

Prerequisites / notice
Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

851-0228-00L Formation of Knowledge in STEM Fields in Primary and Secondary School

Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enroled after successful participation in the course 851-0240-00L “Human Learning (EW1)”.

Abstract
The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of an exchange of expertise: ETH students assist primary and secondary school teachers in STEM lessons.

Objective
Deepening the understanding of knowledge formation and learning processes of primary and secondary students from a cognitive and developmental psychology perspective for students. The assistant ship provides didactic experience and exposure to a different school level (more heterogeneous groups such as for example low-performing to very high-performing Children, language problems etc.)

Content
Students learn more about potentials and deficits of students. They get to know better the early stages of knowledge as well as the formation of misconceptions of students in their subject area. The seminar with assistant-ship includes three phases: In the block seminar misconceptions in the own subject as well as theoretical inputs from developmental and cognitive psychology are discussed. During the assistant ship, a teaching task defined by the primary and secondary teachers is actively taken on in a class. At the end there is the writing of a final report, which includes the description of the knowledge level of the students. This seminar is only suitable for students who can flexibly adapt to the needs of students from lower grades.

Subject Didactics and Professional Training

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

Number Title Type ECTS Hours Lecturers
402-0910-00L Physics Didactics I: Special Didactics of Physics Teaching Limited number of participants.

Further information is available from the lecturer via email: mamohr@ethz.ch

Simultaneous enrolment in Introductory Internship Physics - course 402-0920-00L - is compulsory for Teaching Diploma Physic

Objective
**Content**

Thematische Schwerpunkte
Fachspezifisches: Sachstrukturen der gängigen Unterrichtsthemen, Alltagsbeziehungen, Demonstrations- und Schülerexperimente, Arbeitsmittel zu physikalischen Themen des Grundlagen- und Schwerpunktunterrichts
Einsatz verschiedener Unterrichtsmaterialien: Experimente, Computer, Taschenrechner, Video, Simulation
Unterrichtsformen: Lernaufgabe, Werkstatt, Puzzle, Projekt, Gruppenarbeit, Praktikum
Lernformen
Interaktive Lehr-Lernveranstaltung mit Vorträgen und Demonstrationen des Dozenten, studentischer Einzel- und Kleingruppenarbeit, kurzen Präsentationen der Studierenden, Veröffentlichung der Inhalte durch Bearbeitung von Aufträgen ausserhalb der Kontaktstunden

**Lecture notes**

Folien und weitere Unterlagen werden zur Verfügung gestellt

**Literature**

wird während der Veranstaltung mitgeteilt

**Prerequisites / notice**

Die Veranstaltung ist zusammen mit dem Einführungspraktikum zu belegen

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**402-0915-00L Teaching Internship Including Examination Lessons**

**Physics**

Teaching Internship Physics for TC.
Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.

**Abstract**

Students insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.

**Objective**

- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practice finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

**Content**


Die Themen für die beiden Prüfungslektionen am Schluss des Praktikums erfahren die Studierenden in der Regel eine Woche vor dem Prüfungstermin. Sie erstellen eine Vorbereitung gemäß Anleitung und reichen sie bis am Vortrag um 12 Uhr den beiden Prüfungsexperten (Fachdidaktiker/-in, Departementsvertreter/-in) ein. Die gehaltenen Lektionen werden kriteriumsbasiert beurteilt. Die Beurteilung umfasst auch die schriftliche Vorbereitung und eine mündliche Reflexion des Kandidaten/der Kandidatin über die gehaltenen Lektionen im Rahmen eines kurzen Kolloquiums.

**Lecture notes**

Dokument: schriftliche Vorbereitung für Prüfungslektionen.

**Literature**

Wird von der Praktikumslehrperson bestimmt.

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**402-0917-00L Mentored Work Subject Didactics Physics A**

**Physics**

Mentored Work Subject Didactics in Physics for TC and Teaching Diploma.

**Abstract**

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

**Objective**

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

**Content**

Thematic Focus

The topics of the mentored work are mostly chosen from the high school curriculum.

**Methods**

With the help of the mentor the students individually work on a topic and write a thesis about it.

**Lecture notes**

http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

**Prerequisites / notice**

The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.
Fostered competencies

Subject-specific Competencies
Concepts and Theories - assessed
Techniques and Technologies - assessed

Method-specific Competencies
Analytical Competencies - assessed
Decision-making - assessed
Problem-solving - assessed
Project Management - assessed

Social Competencies
Communication - assessed
Cooperation and Teamwork - assessed
Customer Orientation - assessed
Leadership and Responsibility - assessed
Self-presentation and Social Influence - assessed
Sensitivity to Diversity - assessed

Personal Competencies
Adaptability and Flexibility - assessed
Creative Thinking - assessed
Critical Thinking - assessed
Integrity and Work Ethics - assessed
Self-awareness and Self-reflection - assessed
Self-direction and Self-management - assessed

Specialized Courses in Respective Subject with Educational Focus

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<th>Number</th>
<th>Title</th>
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<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
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</tbody>
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Abstract
Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts.

Objective
- Why is energy important for life and our society?
- How much energy do we need and can it be provided in a way that allows for sustainable existence?
- How did energy use change over time? Which effects did these changes have on the environment?
- What are the physical basics of energy technologies?
- What are the limits and benefits of all the various energy technologies?
- How can different energy technologies be compared?
- Can we understand the changes in the current energy systems?
- How will the energy systems of the future look like?
- How fast can we and should we enforce the current energy transition?
- Which could be the overall guide lines for a working energy system of the future?

Content
1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature
- The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
- Clean Disruption of Energy and Transportation, T. Seba 2014
- Energy and Civilization: A History, V. Smil, 2018

Prerequisites / notice
Basics of Physics applied to Energy and Energy Technology.
Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

402-0922-00L Mentored Work Specialised Courses in Physics with an Educational Focus A

Mentored Work Specialised Courses in the Respective Subject with an Educational Focus in Physics for TC and Teaching Diploma.

Abstract
In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective
- Improvement of the physics education by providing attractive recent topics with regard to future curricular decisions and the public view of physics

Content
Choice of topic by individual arrangement
### Fostered competencies

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<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

**402-0247-00L** Electronics for Physicists I (Analogue)  
*Number of participants limited to 40.*

**Abstract**  
Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology.

**Objective**  
The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

**Content**  
Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC’s and DAC’s, introduction in CMOS technology.

**Practical exercises in small groups to the above themes complement the lectures.**

**Prerequisites / notice**  
no prior knowledge in electronics is required

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>not assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Problem-solving</td>
<td>not assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Critical Thinking</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

**402-0869-00L** Qualitative Methods in Physics  
*W* 6 credits  *2V+1U*  V. Geshkenbein

**Abstract**  
We will discuss, how qualitative thinking allows to progress in different areas of physics, from classical to quantum mechanics, from phase transitions, to developed turbulence and Anderson localisation.

**Objective**  
The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most attractive and beautiful characteristic of this discipline. However, as experience shows, it is just these aspects which are most difficult for beginner. Unfortunately, the methods of theoretical physics are usually presented in a formal, mathematical way, rather than in the constructive form in which they are used in scientific work. The purpose of this lecture course is to make up this deficiency.

**Lecture notes**  
Lecture notes and additional materials are available.

**Physics TC - Key for Type**

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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**Key for Hours**

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
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</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

**ECTS**  
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Physics Teaching Diploma

Detailed information on the programme at: www.didaktischeausbildung.ethz.ch

Education Science

Course offerings in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<td>851-0242-06L</td>
<td>Cognitively Activating Instructions in MINT Subjects</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
<tr>
<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>- Get to know cognitively activating instructions in MINT subjects</td>
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<td></td>
<td>- Get information about recent literature on learning and instruction</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Für eine reibungsfreie Semesterplanung wird um frühe Anmeldung und persönliches Erscheinen zum ersten Lehrveranstaltungstermin ersucht.</td>
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<td>851-0242-07L</td>
<td>Human Intelligence</td>
<td>W</td>
<td>1 credit</td>
<td>1S</td>
<td>E. Stern</td>
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<td></td>
<td>Number of participants limited to 30.</td>
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<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The focus will be on the book &quot;Intelligenz: Grosse Unterschiede und ihre Folgen&quot; by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>- Understanding research methods used in the empirical human sciences</td>
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<td></td>
<td>- Getting to know intelligence tests</td>
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<td></td>
<td>- Understanding findings relevant for education</td>
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<tr>
<td>851-0242-08L</td>
<td>Research Methods in Educational Science</td>
<td>W</td>
<td>1 credit</td>
<td>2S</td>
<td>C. M. Thurn, T. Braas, P. Edelsbrunner</td>
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<td></td>
<td>Number of participants limited to 30.</td>
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<td></td>
<td>This course unit can only be enrolled after successful participation in, or during enrollment in the course &quot;Human Learning (EW 1)&quot;.</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>- Understand research methods used in the empirical educational sciences</td>
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<td></td>
<td>- Understand and critically examine information from scientific journals and media</td>
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<td></td>
<td>- Understand pedagogically relevant findings from the empirical educational sciences</td>
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<tr>
<td>851-0242-11L</td>
<td>Gender Issues In Education and STEM</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>M. Berkowitz Biran, T. Braas, C. M. Thurn</td>
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<td></td>
<td>Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>In this seminar, we introduce some of the major gender-related issues in the context of education and science learning, such as the under-representation of girls and women in science, technology, engineering and mathematics (STEM). Common perspectives, controversies and empirical evidence will be discussed.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues</td>
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<tr>
<td></td>
<td>- To develop a critical view on existing research and perspectives.</td>
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<td></td>
<td>- To integrate this knowledge with teacher's work.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Why do fewer women than men specialize in STEM (science, technology, engineering and mathematics)? Are girls better in language and boys better in math? These and other questions about gender differences relevant to education and STEM learning have been occupying researchers for decades. In this seminar, students learn about major gender issues in the educational context and the different perspectives for understanding them.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).</td>
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<td></td>
<td><strong>see Educational Science Teaching Diploma</strong></td>
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</tbody>
</table>

Subject Didactics in Physics

Important: You can only enrol in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0910-00L</td>
<td>Physics Didactics I: Special Didactics of Physics Teaching</td>
<td>O</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Mohr</td>
</tr>
</tbody>
</table>
Objective

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

The objective is for the students:

- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Content

Thematic Focus

The topics of the mentored work are mostly chosen from the high school curriculum.

Methods

With the help of the mentor the students individually work on a topic and write a thesis about it.

Lecture notes

http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

Prerequisites / notice

The mentored work should usually be finished before the teaching internship. FD2 (402-0909-00L) is required or should be achieved in the same semester.

Fostered competencies

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they compile tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods and Technologies</th>
<th>Analytical Competencies</th>
<th>Decision-making</th>
<th>Problem-solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>Cooperation and Teamwork</td>
<td>Customer Orientation</td>
<td>Leadership and Responsibility</td>
</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
<td>Integrity and Work Ethics</td>
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<tr>
<td></td>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>Self-direction and Self-management</td>
<td></td>
</tr>
</tbody>
</table>

Further information is available from the lecturer via email: mamohr@ethz.ch

Simultaneous enrolment in Introductory Internship Physics - course 402-0920-00L - is compulsory for Teaching Diploma

402-0917-00L Mentored Work Subject Didactics Physics A

| Mentored Work Subject Didactics in Physics for TC and Teaching Diploma. |
|---------------------------|---------------------------|
| Objective | The students verify and test school didactic knowledge for subject lessons in the high school. They can write their own didactic texts, adapt them and develop them with the help of the mentor. The students use the different didactic strategies during the monitoring process and reflect on these in their own way. The students identify the didactic opportunities and challenges of different teaching methods and teaching materials. They can describe the subject didactics content for learning and interpretation and reflect on certain topics from a subject-based and pedagogical angle. |
| Content | The thematic focus of the work is that the students compile tuition materials that are conducive to learning and can adapt these to the point where they are ready for use. |
| Method-specific Competencies | Assessed |
| Social Competencies | Assessed |
| Personal Competencies | Assessed |

402-0918-00L Mentored Work Subject Didactics Physics B
The objective is for the students:
- to be able to familiarise themselves with a tuition topic by consulting different sources, acquiring materials and reflecting on the relevance of the topic and the access they have selected to this topic from a specialist, subject-didactics and pedagogical angle and potentially from a social angle too.
- to show that they can independently compile a tuition sequence that is conducive to learning and develop this to the point where it is ready for use.

Focus of content
The topics of the mentored work are mostly chosen from the high school curriculum.

Methods
With the help of the mentor the students individually work on a topic and write a thesis about it.

Lecture notes
http://www.fachdidaktik.physik.ethz.ch/unterlagen.html

Prerequisites / notice
The mentored work should usually be finished before the teaching internship, FD2 (402-0909-00L) is required or should be achieved in the same semester.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Content</th>
<th>Objective</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
<td>assessed</td>
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</tr>
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<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<tr>
<td>Social Competencies</td>
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<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>assessed</td>
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<td>Negotiation</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
<td>assessed</td>
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<tr>
<td>Creative Thinking</td>
<td>assessed</td>
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<td>Critical Thinking</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
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Professional Training in Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0920-00L</td>
<td>Introductory Internship Physics</td>
<td>O</td>
<td>3</td>
<td>6P</td>
<td>M. Mohr</td>
</tr>
<tr>
<td>402-0911-00L</td>
<td>Teaching Internship Physics</td>
<td>O</td>
<td>8</td>
<td>17P</td>
<td>M. Mohr</td>
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<tr>
<td>402-0913-00L</td>
<td>Teaching Internship Physics II</td>
<td>W</td>
<td>4</td>
<td>9P</td>
<td>M. Mohr</td>
</tr>
</tbody>
</table>

Abstract
During the introductory teaching practice, the students sit in on five lessons given by the teacher responsible for their teaching practice, and teach five lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.

Objective
Right at the start of their training, students acquire initial experience with the observation of teaching, the establishment of concepts for teaching and the implementation of teaching. This early confrontation with the complexity of everything that teaching involves helps students decide whether they wish to and, indeed, ought to, continue with the training. It forms a basis for the subsequent pedagogical and subject-didactics training.

Content

Literature
Wird von der Praktikumslehrperson bestimmt.

Abstract
The teaching practice takes in 50 lessons: 30 are taught by the students, and the students sit in on 20 lessons. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics in their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They acquire the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils’ work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content

Literature
Wird von der Praktikumslehrperson bestimmt.

Prerequisites / notice
Findet in der Regel am Schluss der Ausbildung, vor Ablegung der Prüfungslektionen statt.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1878 of 2416
**Examination Lesson I Physics**

**Objective**

This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures.

**Content**

- To develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- To analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

**Lecture notes**

Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

**Prerequisites / notice**

Nach Abschluss der übrigen Ausbildung.

---

**Examination Lesson II Physics**

**Objective**

On the basis of a specified topic, the candidate shows that they are in a position to:

- To develop and conduct teaching that is conducive to learning at high school level, substantiating it in terms of the subject-matter and from the didactic angle
- To analyze the tuition they have given with regard to its strengths and weaknesses, and outline improvements.

**Lecture notes**

Dokument: Schriftliche Vorbereitung für Prüfungslektionen.

**Prerequisites / notice**

Nach Abschluss der übrigen Ausbildung.

---


Core courses that counted towards the Bachelor or Master programme in physics or comprised additional admission requirements in subject didactics are not eligible for the teaching diploma.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0351-00L</td>
<td>Astronomy</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>H. M. Schmid, A. M. Glauser</td>
</tr>
<tr>
<td>Abstract</td>
<td>An overview of important topics in modern astronomy: planets, sun, stars, milky way, galaxies, and cosmology</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>This lecture gives a general introduction to main topics in modern astronomy. The lecture provides a basis for the more advanced lectures in astrophysics.</td>
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</tr>
<tr>
<td>Content</td>
<td>Planeten, Sonne, Sterne, Milchstrasse, Galaxien und Kosmologie</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Der Neue Kosmos, A. Unsöld, B. Baschek, Springer</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Oder sonstige Grundlehrbücher zur Astronomie.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
<tr>
<td>Abstract</td>
<td>Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts. How much energy do we need and can it be provided in a way that allows for sustainable existence?</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Why is energy important for life and our society? How did energy use change over time? Which effects did these changes have on the environment? What are the physical basics of energy technologies? When, why and how did technology and science of energy come together? What are the limits and benefits of all the various energy technologies? How can different energy technologies be compared? Can we understand the changes in the current energy systems? How will the energy systems of the future look like? How fast can we and should we enforce the current energy transition? Which could be the overall guide lines for a working energy system of the future?</td>
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</tr>
</tbody>
</table>
Content

1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new renewables to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature

The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014
Energy and Civilization: A History, V. Smil, 2018
Renewable Energy – Without the Hot Air, D.J.C. Mackay 2009

Prerequisites / notice

Basics of Physics applied to Energy and Energy Technology.
Training of scientific and multi-disciplinary methods, approaches and their limits in the exercises and discussions.

402-0922-00L  Mentored Work Specialised Courses in Physics with an Educational Focus A

Mentored Work Specialised Courses in the Respective Subject with an Educational Focus in Physics for TC and Teaching Diploma.

Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective

Practice in the explanation of complex topics in physics as the core competence of the teaching profession

Content

Choice of topic by individual arrangement

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

402-0923-00L  Mentored Work Specialised Courses in Physics with an Educational Focus B

Mentored Work Specialised Courses in the Respective Subject with an Educational Focus in Physics for Teaching Diploma and for students upgrading TC to Teaching Diploma.

Abstract

In the mentored work on their subject specialisation, students link high-school and university aspects of the subject, thus strengthening their teaching competence with regard to curriculum decisions and the future development of the tuition. They compile texts under supervision that are directly comprehensible to the targeted readers - generally specialist-subject teachers at high-school level.

Objective

Practice in the explanation of complex topics in physics as the core competence of the teaching profession

Content

Choice of topic by individual arrangement
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Co-credit</th>
<th>Prerequisite / Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0924-00L</td>
<td>Internship Physics Didactics</td>
<td>W</td>
<td>4</td>
<td>9P</td>
<td>M. Mohr, A. Vaterlaus</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>During the Internship Physics Didactics students teach 8 lessons in the classes of an internship teaching person. Students develop, test and analyze teaching arrangement under the guidance of a mentor (one of the lecturers).</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Basic knowledge for the design of teaching arrangements is the topic of the Physics Didactics I and II courses. In the subsequent Internship Physics Didactics students combine the theoretical knowledge acquired in the didactics courses with practical aspects of teaching. During the internship students learn to transform their teaching goals into a real live class room setting considering subject specific, didactical and pedagogical aspects.</td>
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<tr>
<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<tr>
<td></td>
<td>Wird vom Mentor bestimmt.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<tr>
<td></td>
<td>Das Fachdidaktikpraktikum kann erst nach dem Besuch der FD1 und frühestens mit der FD2 durchgeführt werden (eine gleichzeitige Belegung von Fachdidaktik 2 und Fachdidaktikpraktikum ist möglich).</td>
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<tr>
<td>402-0263-00L</td>
<td>Astrophysics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>S. Lilly</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>This introductory course will develop basic concepts in astrophysics as applied to the understanding of the physics of planets, stars, galaxies, and the Universe.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The course provides an overview of fundamental concepts and physical processes in astrophysics with the dual goals of: i) illustrating physical principles through a variety of astrophysical applications; and ii) providing an overview of research topics in astrophysics.</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<td></td>
<td>A comprehensive &quot;script&quot; (240 pages, with detailed derivations) is provided to students. In addition, all powerpoint slides shown in the lectures are provided.</td>
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<tr>
<td>402-0255-00L</td>
<td>Introduction to Solid State Physics</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>C. Degen</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; ionic bonding; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.</td>
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<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>Introduction to Solid State Physics.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; ionic bonding; lattice dynamics, thermal properties of insulators; metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism, superconductivity.</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<tr>
<td></td>
<td>The script will be available on moodle.</td>
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<td></td>
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<tr>
<td></td>
<td>Ibach &amp; Lüth, Festkörperphysik</td>
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<tr>
<td></td>
<td>C. Kittel, Festkörperphysik</td>
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<td></td>
<td>Ashcroft &amp; Mermin, Festkörperphysik</td>
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<td></td>
<td>W. Känzig, Kondensierte Materie</td>
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<td></td>
<td>Prerequisites / notice</td>
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<tr>
<td></td>
<td>Voraussetzungen: Physik I, II, III wünschenswert</td>
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<tr>
<td>402-0247-00L</td>
<td>Electronics for Physicists I (Analogue)</td>
<td>W</td>
<td>4</td>
<td>2V+2P</td>
<td>G. Bison, W. Erdmann</td>
</tr>
<tr>
<td></td>
<td>Number of participants limited to 40.</td>
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<tr>
<td></td>
<td>Abstract</td>
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</tr>
<tr>
<td></td>
<td>Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.</td>
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<tr>
<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC's and DAC's, introduction in CMOS technology. Practical exercises in small groups to the above themes complement the lectures.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<tr>
<td></td>
<td>no prior knowledge in electronics is required</td>
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<tr>
<td></td>
<td>Fostered competencies</td>
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<tr>
<td></td>
<td>Subject-specific Competencies</td>
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<tr>
<td></td>
<td>Concepts and Theories</td>
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<td></td>
<td></td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
<td></td>
<td></td>
<td></td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Decision-making</td>
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<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
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<td></td>
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<td>not assessed</td>
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<tr>
<td></td>
<td>Social Competencies</td>
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<td>not assessed</td>
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<tr>
<td></td>
<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
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<td>not assessed</td>
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<tr>
<td></td>
<td>Adaptable and Flexibility</td>
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<td>not assessed</td>
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<tr>
<td></td>
<td>Creative Thinking</td>
<td></td>
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<td>not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td></td>
<td></td>
<td></td>
<td>not assessed</td>
</tr>
</tbody>
</table>
The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most attractive and beautiful characteristic of this discipline. However, as experience shows, it is just these aspects which are most difficult for beginners. Unfortunately, the methods of theoretical physics are usually presented in a formal, mathematical way, rather than in the constructive form in which they are used in scientific work. The purpose of this lecture course is to make up this deficiency.

Lectures notes

Lecture notes and additional materials are available.

Compulsory Elective Courses

Further course offerings from the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0737-00L</td>
<td>Energy and Sustainability in the 21st Century (Part I)</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Morf</td>
</tr>
<tr>
<td>252-0855-00L</td>
<td>Computer Science in Secondary School Mathematics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>J. Hromkovic, G. Serafini</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1882 of 2416
### Literature

- J. Hromkovic et al.: Lehrwerksreihe "Grundlagen der Informatik für Schweizer Maturitätsschulen"
- J. Hromkovic: Einfach Informatik

### 402-0247-00L  Electronics for Physicists I (Analogue)

**Number of participants limited to 40.**

**Abstract**

Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADCs and DACs, introduction to CMOS technology

**Objective**

The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

**Content**

Passive elements, linear complex networks, transmission lines, simulation of analog circuits (SPICE), semiconductor elements: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise in analog circuits, operational amplifiers, feedback and stability in amplifiers, oscillators, ADC's and DAC's, introduction in CMOS technology.

Practical exercises in small groups to the above themes complement the lectures.

**Prerequisites / notice**

no prior knowledge in electronics is required

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories
  - Techniques and Technologies
- **Method-specific Competencies**
  - Problem-solving
- **Social Competencies**
  - Cooperation and Teamwork
- **Personal Competencies**
  - Creative Thinking
  - Critical Thinking

### 402-0869-00L  Qualitative Methods in Physics

**Number of participants limited to 40.**

**Abstract**

We will discuss, how qualitative thinking allows to progress in different areas of physics, from classical to quantum mechanics, from phase transitions, to developed turbulence and Anderson localisation.

**Objective**

The solution of most problems in theoretical physics begins with the application of the QUALITATIVE METHODS which constitute the most attractive and beautiful characteristic of this discipline. However, as experience shows, it is just these aspects which are most difficult for beginner. Unfortunately, the methods of theoretical physics are usually presented in a formal, mathematical way, rather than in the constructive form in which they are used in scientific work. The purpose of this lecture course is to make up this deficiency.

Lecture notes

Lecture notes and additional materials are available.

**see Compulsory Elective Courses Teaching Diploma**

### Physics Teaching Diploma - Key for Type

- **O** Compulsory
- **W+** Eligible for credits and recommended
- **W** Eligible for credits
- **Z** Courses outside the curriculum
- **Dr** Suitable for doctorate
- **E-** Recommended, not eligible for credits

### Key for Hours

- **V** lecture
- **G** lecture with exercise
- **U** exercise
- **S** seminar
- **K** colloquium
- **P** practical/laboratory course
- **A** independent project
- **D** diploma thesis
- **R** revision course / private study

### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Physics Master

Core Courses

One Core Course in Experimental or Theoretical Physics from Physics Bachelor is eligible; however, this Core Course from Physics Bachelor cannot be used to compensate for the mandatory Core Course in Experimental or Theoretical Physics. For the category assignment keep the choice “no category” and take contact with the Study Administration (www.phys.ethz.ch/studies/study-administration.html) after having received the credits.

Core Courses in Theoretical Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0861-00L</td>
<td>Statistical Physics</td>
<td>W</td>
<td>10 credits</td>
<td>4V+2U</td>
<td>E. Demler</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.</td>
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<tr>
<td></td>
<td>Content</td>
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</tr>
<tr>
<td>Lecture notes</td>
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<tr>
<td>Literature</td>
<td>No specific book is used for the course. Relevant literature will be given in the course.</td>
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<tr>
<td>402-0843-00L</td>
<td>Quantum Field Theory I</td>
<td>W</td>
<td>10 credits</td>
<td>4V+2U</td>
<td>R. Renner</td>
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<td>Special Students UZH must book the module PHYS51 directly at UZH.</td>
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<td>Abstract</td>
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<td>This course discusses the quantisation of fields in order to introduce a coherent formalism for the combination of quantum mechanics and special relativity. Topics include: - Relativistic quantum mechanics - Quantisation of bosonic and fermionic fields - Interactions in perturbation theory - Scattering processes and decays - Elementary processes in QED - Radiative corrections</td>
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<td>Objective</td>
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<td>The goal of this course is to provide a solid introduction to the formalism, the techniques, and important physical applications of quantum field theory. Furthermore it prepares students for the advanced course in quantum field theory (Quantum Field Theory II), and for work on research projects in theoretical physics, particle physics, and condensed-matter physics.</td>
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<td>Lecture notes</td>
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<tr>
<td>Literature</td>
<td>Lecture notes available in English.</td>
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<thead>
<tr>
<th>Fostered competencies</th>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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<tr>
<th>402-0830-00L</th>
<th>General Relativity</th>
<th>W</th>
<th>10 credits</th>
<th>4V+2U</th>
<th>L. Senatore</th>
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<td>Special Students UZH must book the module PHYS51 directly at UZH.</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations of the theory as well as the underlying physical principles and concepts. It covers selected applications, such as the Schwarzschild solution and gravitational waves.</td>
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<td></td>
<td>Basic understanding of general relativity, its mathematical foundations (in particular the relevant aspects of differential geometry), and some of the phenomena it predicts (with a focus on black holes).</td>
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<tr>
<td>Content</td>
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<td>Introduction to the theory of general relativity. The course puts a strong focus on the mathematical foundations, such as differentiable manifolds, the Riemannian and Lorentzian metric, connections, and curvature. It discusses the underlying physical principles, e.g., the equivalence principle, and concepts, such as curved spacetime and the energy-momentum tensor. The course covers some basic applications and special cases, including the Newtonian limit, post-Newtonian expansions, the Schwarzschild solution, light deflection, and gravitational waves.</td>
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## Literature

Suggested textbooks:
- C. Misner, K. Thorne and J. Wheeler: Gravitation
- S. Carroll - Spacetime and Geometry: An Introduction to General Relativity
- R. Wald - General Relativity
- S. Weinberg - Gravitation and Cosmology

### Core Courses: Experimental Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>402-0257-00L</td>
<td>Advanced Solid State Physics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>A. Zheludev</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>This course is an extension of the introductory course on solid state physics.</td>
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<td>The purpose of this course is to learn to navigate the complex collective quantum phases, excitations and phase transitions that are the dominant theme in modern solid state physics. The emphasis is on the main concepts and on specific experimental examples, both classic ones and those from recent research.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The goal is to study how novel phenomena emerge in the solid state.</td>
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<tr>
<td><strong>Content</strong></td>
<td>= Today’s challenges and opportunities in Solid State Physics</td>
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<td></td>
<td>= Phase transitions and critical phenomena</td>
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<td></td>
<td>. Main concepts: coherence length, symmetry, order parameter, correlation functions, generalized susceptibility</td>
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<td>. Landau theory of phase transitions</td>
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<td>. Fluctuations in Landau theory</td>
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<td>. Critical exponents: significance, measurement, inequalities, equalities</td>
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<td>. Scaling, hyperscaling and universality</td>
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<td>. Quantum phase transitions and quantum criticality</td>
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<td>= Fermi surface instabilities</td>
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<td></td>
<td>. The concept of the Landau Fermi liquid in metals</td>
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<td>. Kohn anomalies</td>
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<td>. Charge density waves</td>
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<td>. Metallic ferromagnets and half-metals</td>
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<td>. Spin density waves</td>
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<td>. Superconductivity</td>
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<td>= Magnetism of insulators</td>
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<td>. Magnetic interactions in solids and the spin Hamiltonian</td>
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<td>. Magnetic structures and phase transitions</td>
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<td>. Spin waves</td>
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<td>. Quantum magnetism</td>
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<td>= Electron correlations in solids</td>
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<td></td>
<td>. Mott insulating state</td>
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<td></td>
<td>. Phases of the Hubbard model</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>The printed material for this course involves: (1) a self-contained script, distributed electronically at semester start. (2) experimental examples (Power Point slide-style) selected from original publications, distributed at the start of every lecture.</td>
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<tr>
<td><strong>Literature</strong></td>
<td>A list of books will be distributed. Numerous references to useful published scientific papers will be provided.</td>
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<td><strong>Prerequisites / notice</strong></td>
<td>This course is for students who like to be engaged in active learning. The &quot;exercise classes&quot; are organized in a non-traditional way: following the idea of &quot;less is more&quot;, we will work on only about half a dozen topics, and this gives students a chance to take a look at original literature (provided), and to get the grasp of a topic from a broader perspective.</td>
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<td>Students report back that this mode of &quot;exercise class&quot; is more satisfying than traditional modes, even if it does not mean less effort.</td>
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<tr>
<td>402-0442-00L</td>
<td>Quantum Optics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>A. Imamoglu</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.</td>
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<td><strong>Objective</strong></td>
<td>The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.</td>
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<tr>
<td><strong>Content</strong></td>
<td>- coherence properties of light</td>
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<td>- quantum nature of light: statistics and non-classical states of light</td>
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<td>- light matter interaction: density matrix formalism and Bloch equations</td>
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<td>- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade</td>
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<td>- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,</td>
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<td>- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.</td>
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<tr>
<td><strong>Lecture notes</strong></td>
<td>Selected book chapters will be distributed.</td>
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<td><strong>Literature</strong></td>
<td>Text-books:</td>
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<td></td>
<td>G. Grynberg, A. Aspect and C. Fabre, Introduction to Quantum Optics</td>
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<td></td>
<td>R. Loudon, The Quantum Theory of Light</td>
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<td></td>
<td>Atomic Physics, Christopher J. Foot</td>
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<td></td>
<td>Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin</td>
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<td></td>
<td>C. Cohen-Tannoudji et al., Atom-Photon-Interactions</td>
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<td></td>
<td>M. Scully and M.S. Zubairy, Quantum Optics</td>
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<td></td>
<td>Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics</td>
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<tr>
<td>402-0402-00L</td>
<td>Ultrafast Laser Physics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>L. P. Gallmann, S. Johnson, U. Keller</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.</td>
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Objective

Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.

Content

The lecture covers the following topics:

  a) Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product

  b) Dispersion compensation: technologies for controlling dispersion, pulse shaping, measurement of dispersion

  c) Nonlinear pulse propagation: intensity-dependent refractive index (Kerr effect), self-phase modulation, nonlinear pulse compression, self-focusing, filamentation, nonlinear Schrödinger equation, solitons, non-instantaneous nonlinear effects (Raman/Brillouin), self-steepening, saturable gain and absorption

  d) Second-order nonlinearities with ultrashort pulses: phase-matching with short pulses and real beams, quasi-phase matching, second-harmonic and sum-frequency generation, parametric amplification and generation

  e) Relaxation oscillations: dynamical behavior of rate equations after perturbation

  f) Q-switching: active Q-switching and its theory based on rate equations, active Q-switching technologies, passive Q-switching and theory

  g) Active modelocking: introduction to modelocking, frequency comb versus axial modes, theory for various regimes of laser operation, Haas master equation formalism

  h) Passive modelocking: slow, fast and ideally fast saturable absorbers, semiconductor saturable absorber mirror (SESAM), designs of and materials for SESAMs, modelocking with slow absorber and dynamic gain saturation, modelocking with ideally fast saturable absorber, Kerr-lens modelocking, soliton modelocking, Q-switching instabilities in modelocked lasers, inverse saturable absorption

  i) Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more

  j) Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection

  k) Ultrafast measurements: pump-probe scheme, transient absorption/differential transmission spectroscopy, four-wave mixing, optical gating and more

  l) Frequency combs and carrier-envelope offset phase: measurement and stabilization of carrier-envelope offset phase (CEP), time and frequency domain applications of CEP-stabilized sources

  m) High-harmonic generation and attosecond science: non-perturbative nonlinear optics / strong-field phenomena, high-harmonic generation (HHG), phase-matching in HHG, attosecond pulse generation, attosecond technology: detectors and diagnostics, attosecond metrology (streaking, RABBITT, transient absorption, attoclock), example experiments

  n) Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications

  o) Brief introduction to other hot topics: relativistic and ultra-high intensity ultrafast science, ultrafast electron sources, free-electron lasers, etc.

Prerequisites:

Basic knowledge of quantum electronics (e.g., 402-0275-00L Quantenelektronik).

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

assessed

assessed

Lecture notes

Class notes will be made available.

402-0891-00L

Phenomenology of Particle Physics I

W

10 credits

3V+2U

P. Crivelli, A. de Cosa

Objective

Topics to be covered in Phenomenology of Particle Physics I:

Relativistic kinematics
Decay rates and cross sections
The Dirac equation
From the S-matrix to the Feynman rules of QED
Scattering processes in QED
Experimental tests of QED
Hadron spectroscopy
Unitary symmetries and QCD
QCD and alpha_s running
QCD in e^+e^- annihilation
Experimental tests of QCD in e^+e^- annihilation

Content

Introduction to modern particle physics

Topics to be covered in Phenomenology of Particle Physics I:

Relativistic kinematics
Decay rates and cross sections
The Dirac equation
From the S-matrix to the Feynman rules of QED
Scattering processes in QED
Experimental tests of QED
Hadron spectroscopy
Unitary symmetries and QCD
QCD and alpha_s running
QCD in e^+e^- annihilation
Experimental tests of QCD in e^+e^- annihilation

Literature

As described in the entity: Lernmaterialien

Electives

Electives: Physics and Mathematics

Selection: Solid State Physics
Ultrafast Processes in Solids

There are numerous physical phenomena that rely on time-dependent Hamiltonians (or parametric driving) to amplify, cool, squeeze or couple resonating systems. In this course, we will introduce parametric phenomena in different fields of physics, ranging from classical engineering ideas to devices proposed for quantum neural networks.

This course is intended for:
- experimentalists who desire to gain a solid theoretical understanding of nonlinear driven-dissipative systems,
- theorists looking to expand their analytical and numerical toolbox,
- any scientist interested to learn what lies beyond the harmonic resonator.

In the course, the students will grasp the ubiquitous nature of parametric phenomena and apply it to both classical and quantum systems. The students will understand both the theoretical foundations leading to the parametric drive as well as the experimental aspect related to the realizations of the effect. Each student will analyze an independent system using the tools acquired in the course and will present his/her insights to the class.

This course will provide a general framework for understanding and linking various phenomena, ranging from the child-on-a-swing problem to quantum limited amplifiers, to optical frequency combs, and to optomechanical sensors used in the LIGO experiment. The course will combine theoretical lectures and the study of important experiments through literature.

The students will receive an extended lecture summary as well as numerous MATHEMATICA and Python scripts, including QuTiP notebooks. These tools will enable them to apply analytical and numerical methods to a wide range of systems beyond the duration of the course.

The students should be familiar with wave mechanics as well as second quantization. Following the course requires a laptop with Python and MATHEMATICA installed.

Ultrafast Processes in Solids

Ultrafast processes in solids are of fundamental interest as well as relevant for modern technological applications. The dynamics of the lattice, the electron gas as well as the spin system of a solid are discussed. The focus is on time resolved experiments which provide insight into pico- and femtosecond dynamics.

After attending this course you understand the dynamics of essential excitation processes which occur in solids and you have an overview over state of the art experimental techniques used to study fast processes.

1. Experimental techniques, an overview

2. Dynamics of the electron gas
- 2.1 First experiments on electron dynamics and lattice heating
- 2.2 The finite lifetime of excited states
- 2.3 Detection of lifetime effects
- 2.4 Dynamical properties of reactions and adsorbents

3. Dynamics of the lattice
- 3.1 Phonons
- 3.2 Non-thermal melting

4. Dynamics of the spin system
- 4.1 Laser induced ultrafast demagnetization
- 4.2 Ultrafast spin currents generated by lasers
- 4.3 Landau-Lifschitz-Dynamics
- 4.4 Laser induced switching

5. Correlated materials

Introduction to Magnetism

Atomic paramagnetism and diamagnetism, itinerant and local-moment interatomic coupling, magnetic order at finite temperature, spin precession, approach to equilibrium through thermal and quantum dynamics, dipolar interaction in solids.

- Apply concepts of quantum-mechanics to estimate the strength of atomic magnetic moments and their interactions.
- Identify the mechanisms from which exchange interaction originates in solids (itinerant and local-moment magnetism)
- Evaluate the consequences of the interplay between competing interactions and thermal energy
- Apply general concepts of statistical physics to determine the origin of bistability in realistic magnets.
- Discriminate the dynamic responses of a magnet to different external stimuli.

The lecture “Introduction to Magnetism” is a regular course of the Physics MSc program and aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what “being magnetic” means is essential to address this question properly. Theoretical concepts will be applied to few selected nano-sized magnets, which will serve as clean reference systems.

At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.

Preliminary contents for the HS21:
- Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
- Magnetism in solids (exchange interaction in solids, crystal field).
- Spin resonance and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)
- Magnetic order at finite temperatures (Ising and Heisenberg models, low-dimensional magnetism)
- Dipolar interaction in solids (shape anisotropy, dipolar frustration, origin of magnetic domains)

Learning material will be made available through a dedicated RSStudioServer and through Moodle.

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

Semiconductor Nanostructures

Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.
The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

Objective
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

Content
1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k-p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

Lecture notes

Literature
In addition to the lecture notes, the following supplementary books can be recommended:

Prerequisites / notice
The course is taught in English.

Fostered competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
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<tr>
<td>Social Competencies</td>
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<tr>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
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<tr>
<td>Critical Thinking</td>
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<tr>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-direction and Self-management</td>
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</table>

402-0317-00L Semiconductor Materials: Fundamentals and Fabrication

Abstract
This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective
Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing

Content
1. Fundamentals of Solid State Physics
1.1 Semiconductor materials
1.2 Band structures
1.3 Carrier statistics in intrinsic and doped semiconductors
1.4 p-n junctions
1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
2.1 CZochralski method
2.2 Floating zone method
2.3 High pressure synthesis
3. Semiconductor Epitaxy
3.1 Fundamentals of Epitaxy
3.2 Molecular Beam Epitaxy (MBE)
3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
4.1 Pressure and temperature
4.2 Reflectometry
4.3 Ellipsometry and RAS
4.4 LEED, AES, XPS
4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes
https://moodle-app2.let.ethz.ch/course/view.php?id=

Prerequisites / notice
The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the Moodle page of this lecture.

402-0447-00L Quantum Science with Superconducting Circuits

Abstract
Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.

W 6 credits 2V+1U A. Wallraff, J.-C. Besse, C. Hellings

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1888 of 2416
Objective

Based on today’s most advanced solid state platform for quantum control, the students will learn how to engineer quantum coherent devices and how to use them to process quantum information. The students will acquire both analytical and numerical methods to model the properties and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.

Content


Prerequisites / notice

All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

---

### Selection: Quantum Electronics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0442-05L</td>
<td>Advanced Topics in Quantum Optics</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>T. Esslinger</td>
</tr>
</tbody>
</table>

**Number of participants limited to 25.**

**Abstract**

The lecture will cover current topics and scientific papers in the wider field of quantum optics in an interactive format. First, the research area will be introduced, then several papers of this field will be presented by the students in the style of a journal club. Selected papers will be contrasted and their strengths and weaknesses discussed by the students in panel discussions. Furthermore, the aim of the lecture is to deepen and broaden the knowledge about current research in the field of quantum optics. In addition, it will also be discussed and critically examined how research results are communicated via publications and lectures and which techniques are used in the process.

**Objective**

We will select topical fields in quantum optics and quantum science and discuss recently published work.

Topics:
- Atoms or ions-based quantum computing
- Quantum simulation
- Opto-mechanics
- Driven and dissipative quantum systems
- Cavity based atom-light interaction
- Topological photonics

The interactive part of the lecture will include presentations of recent papers, panel discussions of recent papers and the writing of a critical assessment of an arXiv paper in the style of a referee report.

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0444-00L</td>
<td>Dissipative Quantum Systems</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>A. Imamoglu</td>
</tr>
</tbody>
</table>

**Abstract**

This course builds up on the material covered in the Quantum Optics course. The emphasis will be on quantum optics in condensed-matter systems.

**Objective**

The course aims to provide the knowledge necessary for pursuing advanced research in the field of Quantum Optics in condensed matter systems. Fundamental concepts and techniques of Quantum Optics will be linked to experimental research in systems such as quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

**Content**


**Lecture notes**

Lecture notes will be provided

**Literature**

C. Cohen-Tannoudji et al., Atom-Photon-Interactions (recommended)
Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics (recommended)
A collection of review articles (will be pointed out during the lecture)

**Prerequisites / notice**

Masters level quantum optics knowledge

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>402-0457-00L</td>
<td>Quantum Technologies for Searches of New Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Crivelli, D. Kienzler</td>
</tr>
</tbody>
</table>

**Abstract**

Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

**Objective**

The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

**Content**

The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.
- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

**Prerequisites / notice**

The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>402-0464-00L</td>
<td>Optical Properties of Semiconductors</td>
<td>W</td>
<td>8</td>
<td>2V+2U</td>
<td>G. Scalari, T. Smolenski</td>
</tr>
</tbody>
</table>

**Abstract**

This course presents a comprehensive discussion of optical processes in semiconductors.

The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these material, enabled numerous applications (lasers, LEDs and solar cells) as well as the realization of new physical concepts. Systems that will be covered include quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

**Content**

Electronic states in III-V materials and quantum structures, optical transitions, excitons and polaritons, novel two dimensional semiconductors, spin-orbit interaction and magneto-optics.

**Prerequisites / notice**

Prerequisites: Quantum Mechanics I, Introduction to Solid State Physics

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>402-0465-SBL</td>
<td>Intersubband Optoelectronics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>G. Scalari</td>
</tr>
</tbody>
</table>

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Data: 01.12.2022 12:41  Autumn Semester 2022  Page 1889 of 2416
Abstract
Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent tailorability, this system can be seen as the "ultimate quantum designer's material".

Objective
The goal of this lecture is to explore both the rich physics as well as the application of these systems for sources and detectors. In fact, devices based on intersubband transitions are now unlocking large areas of the electromagnetic spectrum.

Content
The lecture will treat the following chapters:
- Introduction: intersubband optoelectronics as an example of quantum engineering
- Technological aspects
- Electronic states in semiconductor quantum wells
- Intersubband absorption and scattering processes
- Mid-IR and THz ISB Detectors
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
  - Mid-IR QCLs
  - THZ QCLs (direct and non-linear generation)
- Further electronic confinement: interlevel Qdot transitions and magnetic field effects
- Strong light-matter coupling in Mid-IR and THz range

Lecture notes
The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Literature
Mostly the original articles, other useful reading can be found in:
- E. Rosencher and B. Vinter, Optoelectronics, Cambridge Univ. Press
- G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press

Prerequisites / notice
Requirements: A basic knowledge of solid-state physics and of quantum electronics.

402-0467-00L  Quantum Science with Rydberg Atoms  W  4 credits  2V  W. Xu

Abstract
Experimental platforms based on Rydberg atoms is promising for implementing quantum technologies, including quantum nonlinear optics, quantum simulation, quantum computation and sensing. This course covers the basic properties of Rydberg atoms, the state-of-art experimental systems based on Rydberg atoms, and their variety applications for implementing quantum information science.

Objective
By the end of this course, students will be able to
- Learn the basic properties of Rydberg atoms and explain the advantages of using Rydberg atoms for quantum science.
- Learn several experimental schemes to build the state-of-art quantum hardware based on Rydberg atoms, including free-space approach, Rydberg atoms in an optical cavity, and programmable arrays of Rydberg atoms.
- Discuss several near-term applications in quantum information science, including how to use the arrays of Rydberg atoms to simulate quantum many-body systems and to perform quantum logic operations for quantum computation, how to facilitate precise control over individual photons with Rydberg atoms, and so on.

Content
This course will focus on quantum science with Rydberg atoms. It aims to cover both theoretical and experimental aspects. Topics which will be covered include:
- A brief review of quantum technologies
- Properties of Rydberg atoms
- Quantum nonlinear optics with Rydberg atoms
  - Engineering photon-photon interactions with Rydberg polaritons in free space
  - Performing photonic quantum gate operations with Rydberg atoms in optical cavity systems
- Quantum simulation with arrays of Rydberg atoms
  - Simulating quantum spin models with arrays of Rydberg atoms (including the study on quantum phase transitions, quantum dynamics, and so on)
- Quantum computation with Rydberg atoms
  - Encoding qubits with atoms and performing quantum gate operations with Rydberg atoms
  - Start-of-art schemes for achieving general purpose quantum computation and current limitations
- Near-term applications in quantum optimizations

Prerequisites / notice
This course requires a good working knowledge in non-relativistic quantum mechanics. Prior knowledge of quantum optics is recommended but not required.

402-0468-15L  Nanomaterials for Photonics  W  6 credits  2V+1U  R. Grange

Abstract
The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

Objective
The students will acquire theoretical and experimental knowledge about the different types of nanomaterials (semiconductors, metals, dielectric, carbon-based, ...) and their uses as building blocks for advanced applications in photonics (optoelectronics, plasmonics, photonic crystal, ...). Together with the exercises, the students will learn (1) to read, summarize and discuss scientific articles related to the lecture, (2) to estimate order of magnitudes with calculations using the theory seen during the lecture, (3) to prepare a short oral presentation and report about one topic related to the lecture, and (4) to imagine an original photonic device.
Content

1. Introduction to nanomaterials for photonics
   a. Classification of nanomaterials
   b. Light-matter interaction at the nanoscale
   c. Examples of nanophotonic devices

2. Wave physics for nanophotonics
   a. Wavelength, wave equation, wave propagation
   b. Dispersion relation
   c. Interference
   d. Scattering and absorption
   e. Coherent and incoherent light

3. Analogies between photons and electrons
   a. Quantum wave description
   b. How to confine photons and electrons
   c. Tunneling effects

4. Characterization of Nanomaterials
   a. Optical microscopy: Bright and dark field, fluorescence, confocal, High resolution: PALM (STORM), STED
   b. Light scattering techniques: DLS
   c. Near field microscopy: SNOM
   d. Electron microscopy: SEM, TEM
   e. Scanning probe microscopy: STM, AFM
   f. X-ray diffraction: XRD, EDS

5. Fabrication of nanomaterials
   a. Top-down approach
   b. Bottom-up approach

6. Plasmonics
   a. What is a plasmon, Drude model
   b. Surface plasmon and localized surface plasmon (sphere, rod, shell)
   c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering
   d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication
   e. Applications

7. Organic and inorganic nanomaterials
   b. Carbon nanotubes: properties, bandgap description, fabrication
   c. Graphene: motivation, fabrication, devices
   d. Nanomarkers for biophotonics

8. Semiconductors
   a. Crystalline structure, wave function
   b. Quantum well: energy levels equation, confinement
   c. Quantum wires, quantum dots
   d. Optical properties related to quantum confinement
   e. Example of effects: absorption, photoluminescence
   f. Solid-state-lasers: edge emitting, surface emitting, quantum cascade

9. Photonic crystals
   a. Analogy photonic and electronic crystal, in nature
   b. 1D, 2D, 3D photonic crystal
   c. Theoretical modelling: frequency and time domain technique
   d. Features: band gap, local enhancement, superprism...

10. Nanocomposites
    a. Effective medium regime
    b. Metamaterials
    c. Multiple scattering regime
    d. Complex media: structural colour, random lasers, nonlinear disorder

Lecture notes

Slides and book chapter will be available for downloading

Literature

References will be given during the lecture

Prerequisites / notice

Basics of solid-state physics (i.e. energy bands) can help

402-0484-00L Experimental and Theoretical Aspects of Quantum Gases

W 6 credits 2V+1U T. Esslinger

Abstract

Quantum Gases are the most precisely controlled many-body systems in physics. This provides a unique interface between theory and experiment, which allows addressing fundamental concepts and long-standing questions. This course lays the foundation for the understanding of current research in this vibrant field.

Objective

The lecture conveys a basic understanding for the current research on quantum gases. Emphasis will be put on the connection between theory and experimental observation. It will enable students to read and understand publications in this field.
Cooling and trapping of neutral atoms
Bose and Fermi gases
Ultracold collisions
The Bose-condensed state
Elementary excitations
Vortices
Superfluidity
Interference and Correlations
Optical lattices

Lecture notes
notes and material accompanying the lecture will be provided

Literature

Selection: Particle Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>402-0457-00L</td>
<td>Quantum Technologies for Searches of New Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>P. Crivelli, D. Kienzler</td>
</tr>
</tbody>
</table>

Abstract
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

Objective
The aim of this course is to equip students of different backgrounds with a solid base to follow this rapidly developing and exciting multi-disciplinary field.

Content
The first lectures will be dedicated to review the open questions of the Standard Model and the different Beyond Standard Model extensions which can be probed with quantum technologies. This will include searches for dark sector, dark matter, axion and axion-like particles, new gauge bosons (e.g. Dark photons) and extra short-range forces.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics:
- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

Prerequisites / notice
The preceding attendance of introductory particle physics, quantum mechanics and quantum electronics courses at the bachelor level is recommended.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
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<tbody>
<tr>
<td>402-0715-00L</td>
<td>Low Energy Particle Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>A. S. Antognini, P. A. Schmidt-Wellingburg</td>
</tr>
</tbody>
</table>

Abstract
Low energy particle physics provides complementary information to high energy physics with colliders. In this lecture, we will concentrate on flagship experiments which have significantly improved our understanding of particle physics today, concentrating mainly on precision experiments with neutrons, muons and exotic atoms.

Objective
You will be able to present and discuss:
- the principle of the experiments
- the underlying technique and methods
- the context and the impact of these experiments on particle physics

Content
Low energy particle physics provides complementary information to high energy physics with colliders. At the Large Hadron Collider one directly searches for new particles at energies up to the TeV range. In a complementary way, low energy particle physics indirectly probes the existence of such particles and provides constraints for "new physics", making use of high precision and high intensities.

Besides the sensitivity to effects related with new physics (e.g. lepton flavor violation, symmetry violations, CPT tests, search for electric dipole moments, new low mass exchange bosons etc.), low energy physics provides the best test of QED (electron g-2), the best tests of bound-state QED (atomic physics and exotic atoms), precise determinations of fundamental constants, information about the CKM matrix, precise information on the weak and strong force even in the non-perturbative regime etc.

Starting from a general introduction on high intensity/high precision particle physics and the main characteristics of muons and neutrons and their production, we will then focus on the discussion of fundamental problems and ground-breaking experiments:
- search for rare decays and charged lepton flavor violation
- electric dipole moments and CP violation
- spectroscopy of exotic atoms and symmetries of the standard model
- what atomic physics can do for particle physics and vice versa
- neutron decay and primordial nucleosynthesis
- atomic clock
- Penning traps
- Ramsey spectroscopy
- Spin manipulation
- neutron-matter interaction
- ultra-cold neutron production
- various techniques: detectors, cryogenics, particle beams, laser cooling,...
| Literature | Golub, Richardson & Lamoreaux: "Ultra-Cold Neutrons"  
|           | Rauch & Werner: "Neutron Interferometry"  
|           | Carlile & Willis: "Experimental Neutron Scattering"  
|           | Byrne: "Neutrons, Nuclei and Matter"  
|           | Klapdor-Kleingrothaus: "Non Accelerator Particle Physics" |
| Prerequisites / notice | Einführung in die Kern- und Teilchenphysik / Introduction to Nuclear- and Particle-Physics |

<table>
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<th>Course Code</th>
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<th>Credits</th>
<th>Hours</th>
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<tr>
<td>402-0767-00L</td>
<td>Neutrino Physics</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>A. Rubbia, D. Sgalaberna</td>
</tr>
</tbody>
</table>

**Abstract**
Theoretical basis and selected experiments to determine the properties of neutrinos and their interactions (mass, spin, helicity, chirality, oscillations, interactions with leptons and quarks).

**Objective**
Introduction to the physics of neutrinos with special consideration of phenomena connected with neutrino masses.

**Lecture notes** Script

**Literature**


D.O. Caldwell, Current Aspects of Neutrino Physics, Springer.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>402-0725-00L</td>
<td>Experimental Methods and Instruments of Particle Physics</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>U. Langenegger, T. Schietinger, University lecturers</td>
</tr>
</tbody>
</table>

**Abstract**

**Objective**
Acquire an in-depth understanding and overview of the essential elements of experimental methods in particle physics, including accelerators and experiments.

**Content**
1. Examples of modern experiments
2. Basics: Bethe-Bloch, radiation length, nucl. interaction length, fixed-target vs. collider, principles of measurements: energy- and momentum-conservation, etc
3. Physics and layout of accelerators
4. Charged particle tracking and vertexing
5. Calorimetry
6. Particle identification
7. Analysis methods: invariant and missing mass, jet algorithms, b-tagging
8. Special detectors: extended airshower detectors and cryogenic detectors
9. MC simulations (GEANT), trigger, readout, electronics

**Lecture notes** Slides are handed out regularly, see http://www.physik.uzh.ch/en/teachingPHY461/

**Fostered competencies**
Subject-specific Competencies: Concepts and Theories assessed
Techniques and Technologies assessed

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>402-0777-00L</td>
<td>Particle Accelerator Physics and Modeling I</td>
<td>W</td>
<td>6</td>
<td>2V+1U</td>
<td>A. Adelmann</td>
</tr>
</tbody>
</table>

**Abstract**
This is the first of two courses, introducing particle accelerators from a theoretical point of view and covers state-of-the-art modelling techniques.

**Objective**
You understand the building blocks of particle accelerators. Modern analysis tools allows you to model state-of-the-art particle accelerators. In some of the exercises you will be confronted with next generation machines. We will develop a Python (or Julia) simulation tool (pyAccелЕGOrator or jAccелЕGOrator) that reflects the theory from the lecture.

**Content**
- Recap of Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

**Lecture notes** Lecture notes

**Prerequisites / notice**
Physics, Computational Science (RW) at BSc. Level

This lecture is also suited for PhD. students

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>402-0851-00L</td>
<td>QCD: Theory and Experiment</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>to be announced, University lecturers</td>
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</table>

**Abstract**
An introduction to the theoretical aspects and experimental tests of QCD, with emphasis on perturbative QCD and related experiments at colliders.

**Objective**
Knowledge acquired on basics of perturbative QCD, both of theoretical and experimental nature. Ability to perform simple calculations of perturbative QCD, as well as to understand modern publications on theoretical and experimental aspects of perturbative QCD.

**Content**
QCD Lagrangian and Feynman Rules
QCD running coupling
Parton model
DGLAP
Basic processes
Experimental tests at lepton and hadron colliders
Measurements of the strong coupling constant

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Data: 01.11.2022 12:41  
Autumn Semester 2022  
Page 1893 of 2416
The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and programming techniques and scientific software libraries. Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic phenomena such as criticality, superconductivity, cavity QED applications.

Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

lecture notes and slides are available online and will be distributed if desired. Literature recommendations and references are included in the lecture notes. Lecture and exercise lessons in English, exams in German or in English

Prerequisites / notice
For students of both ETH and University of Zurich.

<table>
<thead>
<tr>
<th>Number</th>
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<td>Quantum Information Theory</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U</td>
<td>J. Renes</td>
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<td>W</td>
<td>6 credits</td>
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<td>Advanced Methods in Quantum Many-Body Theory</td>
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<td>8 credits</td>
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<td>Introduction to Computational Physics</td>
<td>W</td>
<td>8 credits</td>
<td>2V+2U</td>
<td>A. Adelmann</td>
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<tr>
<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>W</td>
<td>5 credits</td>
<td>4G</td>
<td>R. Käppeli</td>
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<tr>
<td>402-0845-61L</td>
<td>Effective Field Theories for Particle Physics</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Stoffer</td>
</tr>
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Literature
2) R. K. Ellis, W. J. Stirling, B. R. Webber: "QCD and Collider Physics" (Cambridge Monographs on Particle Physics, Nuclear Physics & Cosmology)

ECTS
Distributed via moodle.

The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.

Objective
By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.

Content
Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

Lecture notes and slides are available online and will be distributed if desired. Literature
Nielsen and Chuang, Quantum Information and Computation
Preskill, Lecture Notes on Quantum Computation
Wilde, Quantum Information Theory
Watrous, The Theory of Quantum Information

Prerequisites / notice
The preceding attendance of the scheduled lecture courses "Introduction to Solid State Physics" and "Quantum Mechanics I" are mandatory. The lectures "Quantum Mechanics II" and "Solid State Theory" provide the most optimal conditions to follow this course.

Prerequisites / notice
This class assumes familiarity with quantum mechanics, including second quantization, and condensed matter physics.

Prerequisites / notice
Does not take place this semester.

Prerequisites / notice
This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and supercomputers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell’s equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

Objective
Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem. Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

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Lecture notes and slides are available online and will be distributed if desired.

Literature
Keldysh formalism for nonequilibrium phenomena, variational approaches. Specific models that will be considered include systems with dissipation, polarons, interacting electrons, electron-phonon systems, transport in mesoscopic systems, superconductivity, cavity QED approaches.

Lecture notes
Lecture notes and additional materials are available.

Literature
M. Tinkham "Introduction to Superconductivity"
P. G. de Gennes "Superconductivity Of Metals And Alloys"
A. A. Abrikosov "Fundamentals of the Theory of Metals"
J.B. Ketterson & S.N. Song "Superconductivity"
H. Stolz "Supraleitung" (German)
K. Fossheim & A. Sudbo "Superconductivity: Physics and Applications"

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H. Stolz "Supraleitung" (German)
K. Fossheim & A. Sudbo "Superconductivity: Physics and Applications"

Prerequisites / notice
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Lecture notes
Lecture notes and additional materials are available.

Literature
M. Tinkham "Introduction to Superconductivity"
P. G. de Gennes "Superconductivity Of Metals And Alloys"
A. A. Abrikosov "Fundamentals of the Theory of Metals"
J.B. Ketterson & S.N. Song "Superconductivity"
H. Stolz "Supraleitung" (German)
K. Fossheim & A. Sudbo "Superconductivity: Physics and Applications"
Abstract
The focus of the course is on Effective Field Theories (EFTs) and their interplay with dispersion theory. These topics will be discussed both in general terms and with specific phenomenological applications in the context of physics beyond the Standard Model, effective description of the weak interaction, as well as the description of non-perturbative strong interaction at low energies.

Objective
This course covers the basic concepts of effective field theories (EFTs) and dispersion theory. We will start by introducing the core concept of constructing EFTs and apply them to the low-energy description of the weak interaction and the effective description of heavy physics beyond the Standard Model.

In the next part of the course, we will discuss Chiral Perturbation Theory (ChPT), the low-energy effective theory of Quantum Chromodynamics (QCD). We will briefly discuss the application of this concept to describe a class of theories beyond the SM in which the SM Higgs arises as a composite state of a new confining sector.

The second focus of the course is on dispersion theory and its interplay with EFTs. We will discuss how to make use of the constraints from unitarity of the S-matrix and analyticity of scattering amplitudes, in order to extend the range of validity of the theoretical description compared to pure EFT methods. We will also discuss how to obtain constraints on EFT parameters from unitarity and analyticity. We will discuss the application of these methods both in the context of low-energy strong interaction and physics beyond the Standard Model.

Content
- Introduction to Effective Field Theories
- Decoupling and matching
- Renormalization group resummation
- The Standard Model Effective Field Theory (SMEFT)
- Chiral Lagrangians
- Unitarity of the S-matrix
- Analyticity and dispersion relations

Prerequisites / notice
QFT-I (mandatory) and QFT-II (highly recommended)
A basic knowledge of Feynman rules in scalar field theories and in Yang-Mills theory is assumed.
QFT-I, QFT-II and Introduction to Quantum ChromoDynamics are highly recommended.

**Quantum Chromodynamics**

**W 6 credits 2V+1U**

**T. K. Gehrmann**

*Does not take place this semester.*

**Abstract**
The course presents the quantum field theory of the strong interaction (quantum chromodynamics, QCD) and discusses its applications to particle physics observables.

**Objective**
The course aims to familiarize its students with the concepts and applications of QCD and to introduce them to modern techniques for computations in QCD.

**Content**
- Review of non-Abelian gauge theories and their quantization
- Spinor-helicity formalism
- Renormalization of QCD and running coupling constant
- Basic strong interaction processes
- Perturbation theory techniques: loops and phase space
- QCD perturbation theory and applications
- Proton structure in QCD
- Resummation of large logarithmic corrections
- Effective field theories
- Non-perturbative methods

**Introduction to String Theory**

**W 6 credits 2V+1U**

**D. Lust, S. Theisen, Lectures on String Theory, Lecture Notes in Physics, Springer (1989).**

**B. Zwiebach, A First Course in String Theory, CUP (2004).**

**J. Polchinski, String Theory I & II, CUP (1998).**

**Prerequisites / notice**
- The course assumes prior knowledge of the content of the quantum field theory 1+2 lectures.

**Higgs Physics**

**W 6 credits 2V+1U**

**M. Donegà, M. Grazzini**

*Special Students UZH must book the module PHY567 directly at UZH.*

**Abstract**
This year we celebrate the tenth anniversary of the discovery of the Higgs boson.

With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background and learn about the main experimental methods used to study the physics the Higgs boson.

**Objective**
With this course the students will receive a detailed introduction to the physics of the Higgs boson in the Standard Model. They will acquire the necessary theoretical background to understand the main production and decay channels of the Higgs boson at high-energy colliders, and the corresponding experimental signatures.

**Content**
- the Standard Model and the mass problem: WW scattering and the no-lose theorem
- the Higgs mechanism and its implementation in the Standard Model
- radiative corrections and the screening theorem
- theoretical constraints on the Higgs mass; the hierarchy problem
- Higgs production in e+e- collisions
- Higgs production at hadron colliders
- Higgs decays to fermions and vector bosons
- Higgs differential distributions, rapidity distribution, pt spectrum and jet vetoes
- Higgs properties and beyond the Standard Model perspective
- Outlook: The Higgs sector in weakly coupled and strongly coupled new physics scenarios.

**Experimental part:**
- basics of accelerators and detectors
- reminders of statistics: likelihoods, hypothesis testing
- reminders of multivariate techniques: Boosted Decision Trees and Neural Networks

**Main topics:**
- pre-history (pre-LEP)
- LEP1: measurements at the Z-pole
- Electroweak constraints
- LEP2: towards the limit mH<114 GeV
- TeVatron searches
- LHC
  -- main channels overview
  -- dissect one analysis
  -- combine information from all channels
  -- differential measurements
  -- off-shell measurements
1. Introduction: research projects in astronomical observations

The course shall provide a basic understanding of the potential and limitation of different types of modern astronomical observations for early career researchers. The course will present technical aspects which are important to prepare, to carry out and to calibrate different types of astronomical measurements: photometry, spectroscopy, astrometry, polarimetry and others. Many practical examples will be discussed including methods for the detection of physical samples of cosmic dust. Also scientific aspects of instrumental projects and observational programs are addressed. An opportunity to contribute to solar spacecraft operations will be available during the course.

Content
- Introduction: research projects in astronomical observations
- Observables: electromagnetic radiation, particles
- Optical telescopes: Optics, types, mechanical concepts, examples
- Detectors: CCDs, IR detectors, basic data reduction steps
- Photometry: signal extraction, calibration, faint sources, etc.
- Spectroscopy: spectrograms, calibration, spectral features
- Introduction to solar space instrumentation
- Space observations of cosmic dust: introduction, remote sensing, in situ instruments, sample return, calibration, data analysis and practical examples
- Specules and adaptive optics: atmosphere, AO-systems
- Polarimetry: measuring principles
- Interferometry

Lecture notes
Notes will be distributed.

Literature
The field of space research and exploration is intrinsically interdisciplinary. Cutting edge space activities are dominated by an interplay of various scientific disciplines and technologies. This course reviews the formation processes of terrestrial- and gaseous planets, and their moons. It provides a basic understanding on how our Solar System came to be, and how other planetary systems form, as well as how/when planets & moons can be habitable places for life.

**Objective**
Overview the state of the art planet- and moon formation models and identify open questions in the field. Understanding the formation process of planetary systems, and the formation of habitable worlds.

**Content**
1) Planet types
2) The Solar System planets
3) Extrasolar Planets
4) The protoplanetary disk where planets are forming. The initial conditions for planet formation.
5) The formation of the building blocks of planets (so-called "planetesimals")
6) Terrestrial Planet formation
7) Formation models of giant planets
8) Formation of moons
9) Evolution of planetary systems, orbital evolution of planets, resonances, planet-disk interactions
10) Origin of life, habitability, astrobiology

**Literature**
Astrophysics of Planet Formation
Armitage, Philip J.; Second edition – 2020
https://eth.swisscovery.islp.ch/permalink/41SLSP_ETH/lish64/alma99117212978705503

**Prerequisites / notice**
No prerequisites.
Max. 20 participants.

**402-0363-00L** Effective Field Theory in Cosmology

**Abstract**
We will cover several advanced topics in Cosmology where field theoretical techniques are proving useful. We will study Inflation, the theory of its quantum fluctuation, and the Effective Field Theory of Inflation. Then, we will move to the late-time universe, where we will study the formation of structure in the universe with the Effective Field Theory of Large-Scale Structure.

**Objective**
The objective is to learn about field theoretical techniques applied to cosmology.

**402-0368-07L** Lecture Series: Space Research and Exploration

**Abstract**
Lecture Series about topics of space research and exploration consisting of individual talks given by different leading experts from industry and academia.

**Objective**
- experience the interdisciplinary nature of space research and exploration spanning physics, engineering, geosciences, biology and more
- get familiar with the Swiss space research and industry sector
- improve their report writing skills by reflecting on the talks
- enhance their communication skills by broadening their research horizon
- have the opportunity for direct learning by posing questions to the presenter in a moderated Q&A.

**Confirmed list of speakers include:**
Adrian Glauser (ETH Zürich)
Andrea Fortier (University of Bern)
Andreas Schrader (Oerlikon Additive Manufacturing)
Anna Kubik (ETH Zürich)
Claude Nicollor (EPFL, ESA Astronaut)
Deborah Müller (Space Exchange Switzerland)
Florian Kehl (UZH, HSLU, NASA-JPL)
Hendrik Kolvenbach (ETH Zürich)
Louise Harra (ETH Zürich, PMOD/WRC)
Maximilian Kirchhoff (Beyond Gravity)
Sascha P. Quanz (ETH Zürich)
Didier Queloz (ETH Zürich)
Thomas Reiter (ESA Astronaut)
Jennifer Wadsworth (UZH)

**402-0368-11L** Earth - A (Unique?) Habitable Planet

**Abstract**
While thousands of extrasolar planets are known to orbit stars other than the Sun, Earth is - until now - the only planet known to be habitable. This lecture takes an interdisciplinary view on Earth as a habitable planet, how it formed, evolved, allowed life to flourish, and how its future might look like. Would we be able to identify another Earth-like planet amongst the population of exoplanets?

**Objective**
Attending students will
- understand Earth place in the cosmos
- learn tools to discern the history of Earth and other planets
- explore the origin and co-evolution of Earth and life
- put Earth in context with extrasolar planets

**Content**
This lecture focuses on our home planet - Earth - from an interdisciplinary perspective. As the search for habitable - and potentially even inhabited - extrasolar planets is one of the most dynamic research fields in modern astrophysics, understanding what makes a planet habitable is a topic of increasing importance; and a highly interdisciplinary topic. In broad brushes, this lecture will discuss the building blocks of planetary systems and their formation, how we can learn about the history of Earth and other planets, what major epochs we can identify over the course of Earth's 4.5 billion year history, when life first appeared on Earth and what impact it had on Earth's evolution, how the future Earth might look like, and - last but certainly not least - how we can search for an Earth-like planet in our cosmic neighbourhood and what our chances are to be successful.

**402-0371-62L** Cosmological Probes

**Abstract**
Our understanding of the universe has made great progress recently thanks to the combination of several cosmological probes such as the cosmic microwave background, galaxy clustering, gravitational lensing, and supernovae. After a review of cosmology, this course will cover the physics of these different probes along with their application, combination and use to measure cosmological parameters.

**Objective**
The goal of this course is to provide an understanding of the physics, application and combination of cosmological probes, and highlight current research topics.
Cosmic dust is an important building block for planets and towards life. This course provides students with a basic understanding of the science of cosmic dust in the solar system, and how to measure it with space-based satellites and instrumentation. The lectures include the physical processes of both interplanetary and interstellar dust, trajectory simulations (i.e. orbital dynamics), in situ measurement techniques, and mission design aspects.

Objective
Cosmic dust is an important building block for planets and towards life. This course provides students with a basic understanding of the science of cosmic dust in the solar system, and how to measure it with space-based satellites and instrumentation. The lectures include the physical processes of both interplanetary and interstellar dust, trajectory simulations (i.e. orbital dynamics), in situ measurement techniques, and mission design aspects.

At the end of the course, students are able to classify the different types of dust in the solar system, and to relate them to their sources, sinks, their importance for planetary science and astronomy, physical processes, and appropriate measurement techniques. They will be able to simulate dust trajectories and use them to gain insight in how orbital dynamics and the space environment shape them. Students can design a basic concept of a space mission for dust measurements. The skills taught in this course will be useful to students in a broader way for planetary sciences.

Content
1. Introduction, course outline, historical notes, interstellar and interplanetary dust, dust in the solar system, sources, sinks, importance for science
2. Dust instrumentation and observables: ground-based, space-based and sample return techniques, calibration of dust instruments in the lab
3. Dust dynamics: recap basic aspects of orbital dynamics, the SPICE toolkit, types of orbits
4. Dust dynamics: space environment, dust processes and implications (e.g. in the early solar system), dust charging, consequences for dynamics, comparison with spacecraft dynamics
5. Dust models and dust data analysis: types of models and their limitations, data analysis
6. Mission design aspects: orbits, mission design limitations, advantages, disadvantages, instrument accommodation, example missions

Lecture notes
Slides will be provided before each lecture.

Literature
Interplanetary dust (freely available online)
https://link.springer.com/book/10.1007/978-3-642-56428-4

Prerequisites / notice
The exercise solutions are performed in the Julia programming language.
Abstract

Part I of this course covers the energy-related topics of this two-semester course. The importance of energy to life and our modern culture is reflected upon and placed in the perspective of the ongoing energy transition in conjunction with the necessary and urgent decarbonization efforts.

Objective

Why is energy important for life and our society?

How did energy use change over time? Which effects did these changes have on the environment?

What are the physical basics of energy technologies?

When, why and how did technology and science of energy come together?

What do the limits and benefits of all the various energy technologies?

How can different energy technologies be compared?

Can we understand the changes in the current energy systems?

How will the energy systems of the future look like?

How fast can we and should we enforce the current energy transition?

Which could be the overall guide lines for a working energy system of the future?

Content

1. Introduction to Energy – what is it all about
2. Energy and making use of it – a short history of energy use and an overview on energy technologies
3. Coal, oil and natural gas – fossil fuels
4. Renewables I: Biomass, Hydropower, and Wind Energy – from traditional use to the modern concepts
5. Renewables II: Geothermal, Tidal power and Solar Technologies – new technologies to lead the change
6. Nuclear power, radioactivity and ultimate storage – the quest for a safe technology
7. Breeding and Nuclear Fusion – can it work at all?
8. Energy Storage – the need to increase capacity and for new technologies
9. Climate Change and Decarbonisation of the Energy Mix – how much time do we have?
11. Energy Systems – how everything can play together
12. Life Cycle Assessment of Energy Technologies – problems and possibilities
14. The Actual Energy Transition and Decarbonisation – How is your 2040, 2050?

Literature

The Physics of Energy, R.L. Jaffe, W. Taylor, 2018
Clean Disruption of Energy and Transportation, T. Seba 2014
Energy and Civilization: A History, V. Smil, 2018

Prerequisites / notice

Basics of Physics applied to Energy and Energy Technology.

Investigation on current problems (and possible solutions) related to the energy system and the environmental interactions.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

not assessed

Techniques and Technologies

not assessed

Method-specific Competencies

Problem-solving

not assessed

Social Competencies

Cooperation and Teamwork

not assessed

Personal Competencies

Creative Thinking

not assessed

Critical Thinking

not assessed

Prerequisites / notice

no prior knowledge in electronics is required

Abstract

Electronics for Physicists I (Analogue)

Number of participants limited to 40.

Objective

The lecture provides the basic knowledge necessary to understand, design and simulate analog electronic circuits. In the exercises, the concepts can be experienced in a hands-on manner. Every student has the opportunity to go through all steps of an electronic design cycle. Those include designing schematics, generating a printed circuit board layout, and the realization of a soldered prototype.

Content

Passive components, linear networks, transmission lines, simulation of analog circuits, semiconductor components: diodes, bipolar and field-effect transistors, basic amplifier circuits, small signal analysis, differential amplifiers, noise, operational amplifiers, feedback and stability, oscillators, ADC’s and DAC’s, introduction to CMOS technology

Prerequisites / notice

no prior knowledge in electronics is required

Abstract

Multiphysics Modeling and Simulation

This class introduces both theoretical and practical aspects related to the modeling and simulation of multiphysics systems. Students will learn how to set up multiphysics models systematically, and therefore reduce time-consuming trial-and-error. Comsol Multiphysics will be utilized to apply the concepts learned during the lectures to solve exercises.

Objective

As information technology continues its fast-paced evolution, solid-state devices and systems increase in complexity. Engineers and scientists are thus increasingly facing the need to model and simulate their problems numerically where analytic textbook solution cease to exist. Moreover, boundaries between traditional disciplines are harder to maintain, as a proper description of the system might involve phenomena from several domains. Examples include—but not limited to—mechatronics which relies on mechanical, electrical and electronic engineering, and transducers (sensors and actuators) which are by definition devices that convert signals from one physical domain to another. Simulation platforms such as Comsol Multiphysics have truly opened the way to easy multi-domain numerical simulation, offering tools that cover all operations from geometry definition, to meshing, to physics and boundary conditions setting to simulation and result post-processing and analysis in a unified, domain-independent fashion. However, this high degree of freedom has its price, as inexperienced users may face cryptic error messages, incomprehensible or even incorrect results. It is the mission of this course to show how to properly set up a problem by exposing some of the most common misconceptions and pitfalls in multiphysics modeling.

Good practices will be taught that should simplify the modeling process and increase the likelihood of correct results. Examples will mainly come from the fields of mechanics (continuum solid mechanics), electromagnetism (electrostatics and conductive media), heat transfer (conductive not convective) and combinations of these domains.

Content

- Recap of ordinary and partial differential equations
- The Finite Element Method (and the Method of Lines)
- Numerical solvers
- Geometry simplification and discretization
- Continuous and discrete symmetries
- Approximate and simplified formulations; domains of applicability
- Boundary conditions and constraints
- Solution-appropriate discretization; hp-refinement, local/global adaptive meshing
- Ramping of nonlinearities and couplings
- Coupling and segregation of multiphysics

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1900 of 2416
Lecture notes

Lecture handouts will be posted online.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Selection: Neuroinformatics

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<tr>
<td>227-1033-00L</td>
<td>Neuromorphic Engineering I</td>
<td>W</td>
<td>6</td>
<td>2V+3U</td>
<td>T. Debrück, G. Indiveri, S.-C. Liu</td>
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Information for UZH students:
Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH.
Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html

Abstract

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective

Understanding of the characteristics of neuromorphic circuit elements.

Content

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

Literature

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice

Particular: The course is highly recommended for those who intend to take the spring semester course 'Neuromorphic Engineering II', that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1037-00L</td>
<td>Introduction to Neuroinformatics</td>
<td>W</td>
<td>6</td>
<td>2V+1U+1A</td>
<td>V. Mante, M. Cook, B. Grewe, G. Indiveri, D. Kiper, W. von der Behrens</td>
</tr>
</tbody>
</table>

Abstract

The course provides an introduction to the functional properties of neurons. Particularly the description of membrane electrical properties (action potentials, channels), neuronal anatomy, synaptic structures, and neuronal networks. Simple models of computation, learning, and behavior will be explained. Some artificial systems (robot, chip) are presented.

Objective

Understanding computation by neurons and neuronal circuits is one of the great challenges of science. Many different disciplines can contribute their tools and concepts to solving mysteries of neural computation. The goal of this introductory course is to introduce the monocultures of physics, maths, computer science, engineering, biology, psychology, and even philosophy and history, to discover the enchantments and challenges that we all face in taking on this major 21st century problem and how each discipline can contribute to discovering solutions.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1901 of 2416
This course considers the structure and function of biological neural networks at different levels. The function of neural networks lies fundamentally in their wiring and in the electro-chemical properties of nerve cell membranes. Thus, the biological structure of the nerve cell needs to be understood if biologically-realistic models are to be constructed. These simpler models are used to estimate the electrical current flow through dendritic cables and explore how a more complex geometry of neurons influences this current flow. The active properties of nerves are studied to understand both sensory transduction and the generation and transmission of nerve impulses along axons. The concept of local neuronal circuits arises in the context of the rules governing the formation of nerve connections and topographic projections within the nervous system. Communication between neurons in the network can be thought of as information flow across synapses, which can be modified by experience. We need an understanding of the action of inhibitory and excitatory neurotransmitters and neuromodulators, so that the dynamics and logic of synapses can be interpreted. Finally, simple neural architectures of feedforward and recurrent networks are discussed in the context of co-ordination, control, and integration of sensory and motor information.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.

### Selection: Medical Physics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>402-0341-00L</td>
<td>Medical Physics I</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>P. Manser</td>
</tr>
</tbody>
</table>

**Abstract**

Introduction to the fundamentals of medical radiation physics. Functional chain due to radiation exposure from the primary physical effect to the radiobiological and medically manifest secondary effects. Dosimetric concepts of radiation protection in medicine. Mode of action of radiation sources used in medicine and its illustration by means of Monte Carlo simulations.

**Objective**

Understanding the functional chain from primary physical effects of ionizing radiation to clinical radiation effects. Dealing with dose as a quantitative measure of medical exposure. Getting familiar with methods to generate ionizing radiation in medicine and learn how they are applied for medical purposes. Eventually, the lecture aims to show the students that medical physics is a fascinating and evolving discipline where physics can directly be used for the benefits of patients and the society.

**Content**

The lecture is covering the basic principles of ionizing radiation and its physical and biological effects. The physical interactions of photons as well as of charged particles will be reviewed and their consequences for medical applications will be discussed. The concept of Monte Carlo simulation will be introduced in the exercises and will help the student to understand the characteristics of ionizing radiation in simple and complex situations. Fundamentals in dosimetry will be provided in order to understand the physical and biological effects of ionizing radiation. Deterministic as well as stochastic effects will be discussed and fundamental knowledge about radiation protection will be provided. In the second part of the lecture series, we will cover the generation of ionizing radiation. By this means, the x-ray tube, the clinical linear accelerator, and different radioactive sources in radiology, radiotherapy and nuclear medicine will be addressed. Applications in radiology, nuclear medicine and radiotherapy will be described with a special focus on the physics underlying these applications.

**Lecture notes**

A script will be provided.

**Prerequisites / notice**

For students of the MAS in Medical Physics (Specialization A) the performance assessment is offered at the earliest in the second year of the studies.

### Selection: Environmental Physics

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1239-00L</td>
<td>Aerosols I: Physical and Chemical Principles</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>M. Gysel Beer, D. Bell, E. Weingartner</td>
</tr>
</tbody>
</table>

**Abstract**

Aerosols I deals with basic physical and chemical properties of aerosol particles. The importance of aerosols in the atmosphere and in other fields is discussed.
Objective

Physical and chemical principles:
The students...
- know the processes and physical laws of aerosol dynamics.
- understand the thermodynamics of phase equilibria and chemical equilibria.
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:
The students...
- know the most important chemical and physical measurement instruments.
- understand the underlying chemistry and physics.

Environmental impacts:
The students...
- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.
- know the most important climate impacts of atmospheric aerosols.
- are aware of the health impacts of atmospheric aerosols.

Lecture notes

material is distributed during the lecture

Literature


Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking not assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

701-0475-00L Atmospheric Physics W 3 credits 2G F. Mahrt

Abstract
This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.

Objective
Students are able
- to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.
- to evaluate the significance of clouds and aerosol particles for artificial weather modification.

Content
The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.

Students also learn to classify radiosondes with the help the thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Lecture notes
Powerpoint slides and chapters from the textbook will be made available on moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15387

Literature

Prerequisites / notice
For certain capters we'll use the concept of "flipped classroom" (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning.

We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.

There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective

Understanding of large-scale atmospheric processes such as the oceanic and land surface processes which drive the climate system is crucial. This lecture course is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic systems - i.e., the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Content

- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes

Dynamics of large-scale atmospheric flow

Literature

- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Prerequisites / notice

Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science (no more than 701-1221-00L) is required.
must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Abstract
Baire category; Banach and Hilbert spaces, bounded linear operators; basic principles: Uniform boundedness, open mapping/closed graph theorem, Hahn-Banach; convexity; dual spaces; weak and weak* topologies; Banach-Alaoglu; reflexive spaces; compact operators and Fredholm theory; closed range theorem; spectral theory of self-adjoint operators in Hilbert spaces.

Objective
Acquire a good degree of fluency with the fundamental concepts and tools belonging to the realm of linear Functional Analysis, with special emphasis on the geometric structure of Banach and Hilbert spaces, and on the basic properties of linear maps.

Literature
Recommended references include the following:


Prerequisites / notice
Solid background on the content of all Mathematics courses of the first two years of the undergraduate curriculum at ETH (most remarkably: fluency with topology and measure theory, in part. Lebesgue integration and L^p spaces).

401-3601-00L Probability Theory W 10 credits 4V+1U W. Werner, D. Schröder

Abstract
At most one of the three course units (Bachelor Core Courses) 401-3461-00L Functional Analysis I 401-3531-00L Differential Geometry I 401-3601-00L Probability Theory can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Objective
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content
This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes
will be available in electronic form.

Literature
H. Bauer, Probability Theory, de Gruyter 1996
J. Jacob and P. Protter, Probability essentials, Springer 2004
A. Klenke, Wahrscheinlichkeitstheorie, Springer 2006
D. Williams, Probability with martingales, Cambridge University Press 1991

401-3621-00L Fundamentals of Mathematical Statistics W 10 credits 4V+1U S. van de Geer

Abstract
The course covers the basics of inferential statistics.

Fourier Analysis

Number Title Type ECTS Hours Lecturers
401-7851-00L Theoretical Astrophysics (University of Zurich) W 10 credits 4V+2U University lecturers

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: ASTS12

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1905 of 2416
This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

**Literature**

Course Materials:
1. The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
2. The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
3. Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
4. Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
5. Galactic Dynamics, James Binney and Scott Tremaine

**Prerequisites / notice**

This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

**Course Materials:**
1. The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
2. The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
3. Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
4. Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
5. Galactic Dynamics, James Binney and Scott Tremaine

**Prerequisites:**
- Introduction to Astrophysics
- Mathematical Methods for the Physicist
- Quantum Mechanics
- Mechanics
- Quantum Mechanics and atomic physics
- Thermodynamics
- Fluid Dynamics
- Electrodynamics

**Content**

1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

**Literature**

Galactic Dynamics (Binney & Tremaine, Princeton University Press),
Computer Simulation using Particles (Hockney & Eastwood CRC press),
Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

**Prerequisites / notice**

Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

**Content**

1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

**Literature**

Galactic Dynamics (Binney & Tremaine, Princeton University Press),
Computer Simulation using Particles (Hockney & Eastwood CRC press),
Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

**Prerequisites / notice**

Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

**Content**

- spherical collapse model, Press-Schechter formalism, applications
- Standard Newtonian and Lagrangian Perturbation Theory
- galaxy bias
- nonlinear relativistic dynamics: ADM formalism
- inflationary models, effective field theory
- modification of gravity
- weak gravitational lensing, CMB anisotropies

**Prerequisites / notice**

Prerequisite: 402-0394-00L Theoretical Astrophysics and Cosmology

**Abstract**

The aim of this lecture is to discuss some advanced topics in general relativity, which are useful to understand the present research activities in the field. A list of possible topics is given below. A basic knowledge of general relativity is required (ideally having followed the lecture on General Relativity). The course is particularly suited for master and PhD students.
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the

ECTS

A. Manera

Two-dimensional irrotational (potential) flows: stream function and potential, complex notation, singularity method, unsteady flow,

G. Haller

Lecture Notes containing copies of the presented slides.

Two-dimensional irrotational (potential) flows: stream function and potential, singularity method, unsteady flow, aerodynamic concepts.

W

Lecturers

Renewable Energy Technologies

S. Glasston & A. Sesonke: Nuclear Reactor Engineering, Reactor System Engineering, Ed. 4, Vol. 2., Springer-Science+Business Media,

Relevant chapters (corresponding to lecture notes) from the textbook

A. Steinfeld

The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes
during the lecture.

2V+2U

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

151-0209-00L

Abstract

Nuclear Energy Conversion

R. L. Murray: Nuclear Energy (Sixth Edition), An Introduction to the Concepts, Systems, and Applications of Nuclear Processes, Elsevier

4 credits

Objective

Content

Lecture notes

Hand-outs will be distributed. Additional literature and information on the website of the lab: https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00l-nuclear-energy-conversion.html

Literature


151-0163-00L

Abstract

Fluid Dynamics II


151-0103-00L

Abstract

Nonlinear Dynamics and Chaos I


151-0532-00L

Abstract

Analysis I/II, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas

Prerequisites / notice

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1907 of 2416
Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0620-00L</td>
<td>Embedded MEMS Lab</td>
<td>W</td>
<td>5</td>
<td>C. Hierold, M. Haluska</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>Practical course: Students are introduced to the process steps required for the fabrication of MEMS (Micro Electro Mechanical System) and carry out the fabrication and testing steps in the clean rooms by themselves. Additionally, they learn the requirements for working in clean rooms. Processing and characterization will be documented and analyzed in a final report. Limited access.</td>
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<td><strong>Objective</strong></td>
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<tr>
<td></td>
<td>Students learn the individual process steps that are required to make a MEMS (Micro Electro Mechanical System). Students carry out the process steps themselves in laboratories and clean rooms. Furthermore, participants become familiar with the special requirements (cleanliness, safety, operation of equipment and handling hazardous chemicals) of working in the clean rooms and laboratories. The entire production, processing, and characterization of the MEMS is documented and evaluated in a final report.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>With guidance from a tutor, the individual silicon microsystem process steps that are required for the fabrication of an accelerometer are carried out:</td>
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<td>- Photolithography, dry etching, wet etching, sacrificial layer etching, various cleaning procedures</td>
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<td>- Packaging and electrical connection of a MEMS device</td>
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<td>- Testing and characterization of the MEMS device</td>
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<td></td>
<td>- Written documentation and evaluation of the entire production, processing and characterization</td>
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<td><strong>Lecture notes</strong></td>
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<td></td>
<td>A document containing theory, background and practical course content is distributed at the Introductory lecture day of the course.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td>The document provides sufficient information for the participants to successfully participate in the course.</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<td>Participating students are required to attend all scheduled lectures and meetings of the course.</td>
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<td></td>
<td>For safety and efficiency reasons the number of participating students is limited. We regret to restrict access to this course by the following rules:</td>
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<tr>
<td></td>
<td>Priority 1: master students of the master's program in &quot;Micro and Nanosystems&quot;</td>
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<tr>
<td></td>
<td>Priority 2: master students of the master's program in &quot;Mechanical Engineering&quot; with a specialization in Microsystems and Nanoscale Engineering (MAVT-tutors Profs Daraio, Dual, Hierold, Koumoutsakos, Nelson, Norris, Poulikakos, Pratsinis, Stemmer), who attended the bachelor course <em>151-0621-00L Microsystems Technology</em> successfully.</td>
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<td>Priority 3: master students, who attended the bachelor course &quot;151-0621-00L Microsystems Technology&quot; successfully.</td>
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<td>Priority 4: all other students (PhD, bachelor, master) with a background in silicon or microsystems process technology.</td>
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<td>If there are more students in one of these priority groups than places available, we will decide by (in following order) best achieved grade from 151-0621-00L Microsystems Technology, registration to this practicum at previous semester, and by drawing lots.</td>
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<td>Students will be notified at the first lecture of the course (introductory lecture) as to whether they are able to participate.</td>
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<td>The course is offered in autumn and spring semester.</td>
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<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0213-00L</td>
<td>Fluid Dynamics with the Lattice Boltzmann Method</td>
<td>W</td>
<td>4</td>
<td>I. Karlin</td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.</td>
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<td>Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.</td>
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<td>During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.</td>
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<td></td>
<td>Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).</td>
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<td>The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.</td>
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<td>Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.</td>
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</table>
The course builds upon three parts:
I. Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II. Theoretical basis of statistical mechanics and kinetic equations.
III. Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows;
   Numerical stability and accuracy.

5. Microrheology:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; Flows with phase transitions.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph.D) but BSc students can also attend.

<table>
<thead>
<tr>
<th>151-0107-20L</th>
<th>High Performance Computing for Science and Engineering (HPCSE) I</th>
<th>W</th>
<th>4 credits</th>
<th>4G</th>
<th>S. M. Martin, J. H. Walther</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering. With manufacturing processes reaching its limits in terms of transistor density on today's computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the &quot;think parallel&quot; mind-set of developers is still lagging behind. The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.</td>
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<tr>
<td>Objective</td>
<td>With manufacturing processes reaching its limits in terms of transistor density on today's computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the &quot;think parallel&quot; mind-set of developers is still lagging behind. The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.</td>
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<tr>
<td>Content</td>
<td>1. Hardware and Architecture: Moore's Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn's taxonomy, Vector instructions (for Intel x86)</td>
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<td>2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)</td>
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<td>3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models</td>
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<td>4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl's Law, Strong and weak scaling analysis</td>
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<td>5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods</td>
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<tr>
<td>Lecture notes</td>
<td><a href="https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/">https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/</a></td>
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<tr>
<td>Literature</td>
<td>Class notes, handouts</td>
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<td></td>
<td>• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann</td>
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<td></td>
<td>• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press</td>
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<td></td>
<td>• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann</td>
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<td>• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press</td>
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<td></td>
<td>Lecture notes</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.</td>
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<table>
<thead>
<tr>
<th>151-0621-00L</th>
<th>Microsystems I: Process Technology and Integration</th>
<th>W</th>
<th>6 credits</th>
<th>3V+3U</th>
<th>M. Haluska, C. Hierold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and devices by a sequence of defined processing steps (process flow). Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (+ process flow).</td>
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<tr>
<td>Objective</td>
<td>Students are introduced to the fundamentals of semiconductors, the basics of micromachining and silicon process technology and will learn about the fabrication of microsystems and devices by a sequence of defined processing steps (process flow). Students are introduced to the basics of micromachining and silicon process technology and will understand the fabrication of microsystem devices by the combination of unit process steps (+ process flow).</td>
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<tr>
<td>Content</td>
<td>- Introduction to microsystems technology (MST) and micro electro mechanical systems (MEMS)</td>
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<td></td>
<td>- Basic silicon technologies: Thermal oxidation, photolithography and etching, diffusion and ion implantation, thin film deposition.</td>
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<td>- Specific microsystems technologies: Bulk and surface micromachining, dry and wet etching, isotropic and anisotropic etching, beam and membrane formation, wafer bonding, thin film mechanical properties.</td>
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<td>Application of selected technologies will be demonstrated on case studies.</td>
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<tr>
<td>Lecture notes</td>
<td>Handouts (available online)</td>
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227-0385-10L Biomedical Imaging

**Abstract**
Introduction to diagnostic medical imaging based on electromagnetic and acoustic fields including X-ray planar and tomographic imaging, radio-tracer based nuclear imaging techniques, magnetic resonance imaging and ultrasound-based procedures.

**Objective**
Upon completion of the course students are able to:
- Explain the physical and mathematical foundations of diagnostic medical imaging systems
- Characterize system performance based on signal-to-noise ratio, contrast-to-noise ratio and transfer function
- Design a basic diagnostic imaging system chain including data acquisition and data reconstruction
- Identify advantages and limitations of different imaging methods in relation to medical diagnostic applications
- Introduction (intro, overview, history)
- Signal theory and processing (foundations, transforms, filtering, signal-to-noise ratio)
- X-rays (production, tissue interaction, contrast, modular transfer function)
- X-rays (resolution, detection, digital subtraction angiography, Radon transform)
- X-rays (filtered back-projection, spiral computed tomography, image quality, dose)
- Nuclear imaging (radioactive tracer, collimation, point spread function, SPECT/PECT)
- Nuclear imaging (detection principles, image reconstruction, kinetic modelling)
- Magnetic Resonance (magnetic moment, spin transitions, excitation, relaxation, detection)
- Magnetic Resonance (plane wave encoding, Fourier reconstruction, pulse sequences)
- Magnetic Resonance (contrast mechanisms, gradient- and spin-echo, applications)
- Ultrasound (mechanical wave generation, propagation in tissue, reflection, transmission)
- Ultrasound (spatial and temporal resolution, phased arrays)
- Ultrasound (Doppler shift, implementations, applications)
- Summary, example exam questions

**Lecture notes**
Lecture notes and handouts

**Literature**
Webb A, Smith N.B. Introduction to Medical Imaging; Physics, Engineering and Clinical Applications; Cambridge University Press 2011

**Prerequisites / notice**
Concepts and Theories

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227-0386-00L Biomedical Engineering

**Abstract**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The focus is on learning the basic vocabulary of biomedical engineering and getting familiar with concepts that govern common medical instruments and the most important organs from an engineering point of view.

**Objective**
Introduction into selected topics of biomedical engineering as well as their relationship with physics and physiology. The course provides an overview of the various topics of the different tracks of the biomedical engineering master course and helps orienting the students in selecting their specialized classes and project locations. It also serves as an introduction to the field for students of the ITET, MAVT, HEST and other bachelor programs.

In addition, the most recent achievements and trends of the field of biomedical engineering are also outlined.

**Content**
History of BME and the role of biomedical engineers. Ethical issues related to BME.
Biomedical sensors both wearable and also biochemical sensors.
Bioelectronics: Nernst equation, Donnan equilibrium, equivalent circuits of biological membranes and bioelectronic devices.
Bioinformatics: genomic and proteomic tools, databases and basic calculations.
Equations describing basic reactions and enzyme kinetics.
Medical optics: Optical components and systems used in hospitals.
Basic concepts of tissue engineering and organ printing.
Biomaterials and their medical applications.
Function of the heart and the circulatory system.
Transport and exchange of substances in the human body, compartment modeling.
The respiratory system.
Bioimaging.
Orthopedic biomechanics.
Lectures (2h), discussion of practical exercises (1h) and homework exercises.

**Lecture notes**
Introduction to Biomedical Engineering by Enderle, Banchard, and Bronzino

**Method-specific Competencies**
- Analysis, Linear algebra, Physics, Basics of signal theory, Basic skills in Matlab/Python programming

**Prerequisites / notice**
No specific requirements, BUT ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).

---

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

**Social Competencies**
- Communication
- Cooperation and Teamwork

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

**Literature**
- S.M. Sze: Semiconductor Devices, Physics and Technology
- W. Menz, J. Mohr, O.Paul: Microsystem Technology
- Hong Xiao: Introduction to Semiconductor Manufacturing Technology
- T. M. Adams, R. A. Layton: Introductory MEMS, Fabrication and Applications

---

**Notice**
ITET, MAVT, PHYS students will have to learn a lot of new words related to biochemistry, biology and medicine, while HEST and BIOL students will have to grasp basic engineering concepts (circuits, equations, etc.).
The course's goal is to give an overview of the contemporary state of consciousness research, with emphasis on the contributions brought.

This seminar reviews the philosophical and phenomenological as well as the neurobiological aspects of consciousness. The subjective features of consciousness are explored, and modern research into its neural substrate, particularly in the visual domain, is explained.

Starting point of the course is the probability theory, which enables to derive step-by-step the two pillars of thermodynamics from the perspective of statistical mechanics: the maximization of entropy according to the Boltzmann’s law as well as the minimization of the Gibbs free energy. Then, an assortment of biological phenomena at the molecular and cellular level (e.g. cytoskeletal polymerization, action potential, photosynthesis, gene regulation, morphogen patterning) will be examined at the light of these two principles with the aim to derive a quantitative expression describing their behavior. Each analytical model is finally validated by comparing it with the corresponding experimental data in the literature.

By the end of the course, students will also learn to critically evaluate the concepts of making an assumption and making an approximation.

Objective of this course is to show that biological phenomena despite their variety can be analytically described using only two principles from statistical mechanics: maximization of the entropy and minimization of the Gibbs free energy.

An extra hour (Mon 17.00 o’clock - 18.00) will be proposed via ZOOM to solve together the exercises of the previous week.

More details about the course can be found on the course’s webpage.

W 3 credits 2V

The course includes discussions of scientific as well as philosophical articles. We review current schools of thought, models of consciousness, and proposals for the neural correlate of consciousness (NCC).

Emphasis is placed on students developing their own thinking through a discussion-centered course structure.

Since we are all experts on consciousness, we expect active participation and discussions!
Literature


Prerequisites / notice

Participants need a good command of
- differentiation and integration of a function with one or more variables (basics of Analysis),
- Newton's and Coulomb's laws (basics of Mechanics and Electrostatics).

Notions of vectors in 2D and 3D are beneficial.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<td>Project Management</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
<td>not assessed</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td></td>
<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Integrity and Work Ethics</td>
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<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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227-0655-00L Nonlinear Optics W 6 credits 2V+2U J. Leuthold

Abstract
Nonlinear Optics deals with the interaction of light with matter. I.e. the response of insulators, metals, semiconductors or metamaterials to light and the mathematical framework (classical and quantum mechanical) to describe the phenomena. It is the goal to understand phenomena such as the refractive index, the electro-optic effect, rectification, harmonic generation, FWM, soliton propagation,...

Objective
The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematical by means of the susceptibility. Participants will be able to designing and invent novel photonic, plasmonic or quantum devices.

Content
Chapter 1: The Wave Equations in Nonlinear Optics
Chapter 2: Nonlinear Effects - An Overview
Chapter 3: The Nonlinear Optical Susceptibility - Classical and Quantummechanical Derivations
Chapter 4: Second Harmonic Generation
Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator
Chapter 6: Acousto-Optic Effect
Chapter 7: Nonlinear Effects of Third Order
Chapter 8: Nonlinear Effects in Media with Gain

Literature
Lecture notes are distributed. For students enrolled in the course, additional information, lecture notes and exercises can be found on moodle (https://moodle-app2.let.ethz.ch/).

Prerequisites / notice
Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics

227-0423-00L Neural Network Theory W 4 credits 2V+1U H. Bölcskei

Abstract
The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective
After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

Content
1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

Lecture notes
Detailed lecture notes are available on the course website https://www.mins.ee.ethz.ch/teaching/int/

Prerequisites / notice
This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

227-0653-00L Electromagnetic Precision Measurements and Optomechanics W 4 credits 2V+1U M. Frimmer

Abstract
The measurement process is at the heart of both science and engineering. Electromagnetic fields have proven to be particularly powerful probes. This course provides the basic knowledge necessary to understand current state-of-the-art optomechanical measurement systems operating at the precision limits set by the laws of quantum mechanics.

Objective
The goal of this course is to understand the fundamental limitations of measurement systems relying on electromagnetic fields.
Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is a flourishing field of fundamental and applied research.

The lecture starts with summarizing the relevant fundamentals of the treatment of noisy signals. We familiarize ourselves with the concept of measurement imprecision in light-based measurement systems. To this end, we consider the process of photodetection and discuss the statistical fluctuations arising from the quantization of the electromagnetic field into photons. We exemplify our insights at hand of concrete examples, such as homodyne and heterodyne photodetection. Furthermore, we focus on the process of measurement backaction, the inevitable result of the interaction of the probe with the system under investigation. The course emphasizes the connection between the taught concepts and current state-of-the-art research carried out in the field of optomechanics.

### Prerequisites / notice
- Electrodynamics
- Physics 1,2
- Introduction to quantum mechanics

### 227-0965-00L Micro and Nano-Tomography of Biological Tissues

#### Objective
Introduction to the basic concepts of X-ray tomographic imaging, image analysis and data quantification at the micro and nano scale with particular emphasis on biological applications.

#### Content
Synchrotron-based X-ray micro- and nano-tomography is today a powerful technique for non-destructive, high-resolution investigations of a broad range of materials. The high-brilliance and high-coherence of third generation synchrotron radiation facilities allow quantitative, three-dimensional imaging at the micro and nanometer scale and extend the traditional absorption imaging technique to edge-enhanced and phase-sensitive measurements, which are particularly suited for investigating biological samples.

The lecture includes a general introduction to the principles of tomographic imaging from image formation to image reconstruction. It provides the physical and engineering basics to understand how imaging beamlines at synchrotron facilities work, looks into the recently developed phase contrast methods, and explores the first applications of X-ray nano-tomographic experiments.

The course finally provides the necessary background to understand the quantitative evaluation of tomographic data, from basic image analysis to complex morphometrical computations and 3D visualization, keeping the focus on biomedical applications.

### Literature
Available online

### 227-0157-00L Semiconductor Devices: Physical Bases and Simulation

#### Objective
The course aims at the understanding of the principle physics of modern semiconductor devices, of the foundations in the physical modeling of transport and its numerical simulation. During the course also basic knowledge on quantum-mechanics, semiconductor physics and device physics is provided. Computer simulations of the most important devices and of interesting physical effects supplement the lectures.

#### Content
The main topics are: transport models for semiconductor devices (quantum transport, Boltzmann equation, drift-diffusion model, hydrodynamic model), physical characterization of silicon (intrinsic properties, scattering processes), mobility of cold and hot carriers, recombination (Shockley-Read-Hall statistics, Auger recombination), impact ionization, metal-semiconductor contact, metal-insulator-semiconductor structure, and heterojunctions. The exercises are focussed on the theory and the basic understanding of the operation of special devices, as single-electron transistor, resonant tunneling diode, pn-diode, bipolar transistor, MOSFET, and laser. Numerical simulations of such devices are performed with an advanced simulation package (Sentaurus-Synopsys). This enables to understand the physical effects by means of computer experiments.

### Literature
The script (in book style) can be downloaded from: https://iis-students.ee.ethz.ch/lectures/

### 227-0663-00L Nano-Optics

#### Objective
Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

#### Content
We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

### Prerequisites / notice
- Electromagnetic fields and waves (or equivalent)
- Physics I+II

### 227-0147-10L VLSI 3: Full-Custom Digital Circuit Design

#### Objective
At the end of this course, you will
- understand the design of the main building blocks of state-of-the-art digital integrated circuits
- be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
- be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
- understand the performance trade-offs between delay, area, and power consumption

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.
The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

**Literature**

N. H. E. Weste and D. M Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

**Prerequisites / notice**

VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

**Fostered competencies**

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Problem-solving

**Abstract**

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

**Objective**

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.

**Content**

- Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.
- Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.
- Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection techniques, Error correction coding.
- Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.
- Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

**Lecture notes**

Lecture notes are handed out.

**Literature**

Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

**Prerequisites / notice**

Content

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes

Textbook and all further documents in English.

Literature


Prerequisites / notice

Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/

252-0834-00L Information Systems for Engineers W 4 credits 2V+1U G. Fourny

Abstract

This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

Objective

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.
Using a relational database

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

Taking a relational database to the next level

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

Analytics on top of a relational database

12. Data cubes

Outlook

13. Outlook

Data cubes

Literature

- Lecture material (slides).
  (It is not required to buy the book, as the library has it)

Prerequisites / notice

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BS and MS

Elementary knowledge of set theory and logic

Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python

Fostered competencies

Subject-specific Competencies
Concepts and Theories: assessed

Techniques and Technologies: assessed

Method-specific Competencies
Analytical Competencies: assessed

Decision-making: assessed

Media and Digital Technologies: not assessed

Problem-solving: not assessed

Social Competencies
Communication: not assessed

Sensitivity to Diversity: not assessed

Negotiation: not assessed

Personal Competencies
Creative Thinking: not assessed

Critical Thinking: not assessed

Integrity and Work Ethics: not assessed

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327-2132-00L Multifunctional Ferroic Materials: Growth and Characterisation

W 2 credits 2G 4 credits M. Trassin

Abstract

The course will explore the growth of (multi-) ferroic oxide thin films. The structural characterization and ferroic state investigation by force microscopy and by laser-optical techniques will be addressed. Oxide electronics device concepts will be discussed.

Objective

Oxide films with a thickness of just a few atoms can now be grown with a precision matching that of semiconductors. This opens up a whole world of functional device concepts and fascinating phenomena that would not occur in the expanded bulk crystal. Particularly interesting phenomena occur in films showing magnetic or electric order or, even better, both of these ("multiferroics").

In this course students will obtain an overarching view on oxide thin epitaxial films and heterostructures design, reaching from their growth by pulsed laser deposition to an understanding of their magnetoelectric functionality from advanced characterization techniques. Students will therefore understand how to fabricate and characterize highly oriented films with magnetic and electric properties not found in nature.

Content

Types of ferroic order, multiferroics, oxide materials, thin-film growth by pulsed laser deposition, molecular beam epitaxy, RF sputtering, structural characterization (reciprocal space - basics-, XRD for thin films, RHEED) epitaxial strain related effects, scanning probe microscopy techniques, laser-optical characterization, oxide thin film based devices and examples.

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327-0703-00L Electron Microscopy in Material Science

W 4 credits 2V+U 4 credits S. Gerstl, R. Erni, F. Gramm, A. Käch, F. Krumeich, K. Kunze

Abstract

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Objective

A comprehensive understanding of the interaction of electrons with condensed matter and details on the instrumentation and methods designed to use these probes in the structural and chemical analysis of various materials.

Content

This course provides a general introduction into electron microscopy of organic and inorganic materials. In the first part, the basics of transmission- and scanning electron microscopy are presented. The second part includes the most important aspects of specimen preparation, imaging and image processing. In the third part, recent applications in materials science, solid state physics, structural biology, structural geology and structural chemistry will be reported.

Lecture notes

will be distributed in English

Literature


Erni: Aberration-corrected imaging in transmission electron microscopy, Imperial College Press (2010, and 2nd ed. 2015)

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327-0702-00L EM-Practical Course in Materials Science

W 2 credits 4P 4P K. Kunze, S. Gerstl, F. Gramm, F. Krumeich, J. Reuteler

Abstract

Practical work on TEM, SEM, FIB and APT treatment of typical problems data analysis, writing of a report
Objective
Application of basic electron microscopic techniques to materials science problems

Literature
see lecture Electron Microscopy (327-0703-00L)

Prerequisites / notice
Attendance of lecture Electron Microscopy (327-0703-00L) is recommended. Maximum number of participants 15, work in groups of 3 people.

327-2125-00L Microscopy Training SEM I - Introduction to SEM
The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP0.html).

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract
This introductory course on Scanning Electron Microscopy (SEM) emphasizes hands-on learning. Using ScopeM SEMs, students have the opportunity to study their own samples (or samples provided) and solve practical problems by applying knowledge acquired during the lectures. At the end of the course, students will be able to apply SEM for their (future) research projects.

Objective
- Set-up, align and operate a SEM successfully and safely.
- Explain important operational parameters of SEM and optimize microscope performance.
- Explain different signals in SEM and obtain secondary electron (SE) and backscatter electron (BSE) images.
- Operate the SEM in low-vacuum mode.
- Make use of EDX for semi-quantitative elemental analysis.

Content
During the course, students learn through lectures, demonstrations, and hands-on sessions how to setup and operate SEM instruments, including low-vacuum and low-voltage applications. This course gives basic skills for students new to SEM. At the end of the course, students are able to align an SEM, to obtain secondary electron (SE) and backscatter electron (BSE) images and to perform energy dispersive X-ray spectroscopy (EDX) semi-quantitative analysis. Emphasis is put on procedures to optimize SEM parameters in order to best solve practical problems and deal with a wide range of materials.

Lectures:
- Introduction on Electron Microscopy and instrumentation
- electron sources, electron lenses and probe formation
- beam/specimen interaction, image formation, image contrast and imaging modes.
- sample preparation techniques for EM
- X-ray micro-analysis (theory and detection), qualitative and semi-quantitative EDX and point analysis, linescan and spectral mapping

Practicals:
- Brief description and demonstration of the SEM microscope
- Practice on image formation, image contrast (and image processing)
- Student participation on sample preparation techniques
- Scanning Electron Microscopy lab exercises: setup and operate the instrument under various imaging modalities
- Practice on real-world samples and report results

Lecture notes
Lecture notes will be distributed.

Literature

Prerequisites / notice
No mandatory prerequisites.

327-2126-00L Microscopy Training TEM I - Introduction to TEM
The number of participants is limited. In case of overbooking, the course will be repeated once. All registrations will be recorded on the waiting list.

For PhD students, postdocs and others, a fee will be charged (https://scopem.ethz.ch/education/MTP0.html).

All applicants must additionally register on this form: (link will follow)

The selected applicants will be contacted and asked for confirmation a few weeks before the course date.

Abstract
The introductory course on Transmission Electron Microscopy (TEM) provides theoretical and hands-on learning for beginners who are interested in using TEM for their Master or PhD thesis. TEM sample preparation techniques are also discussed. During hands-on sessions at different TEM instruments, students will have the opportunity to examine their own samples if time allows.

Objective
Understanding of
1. the set-up and individual components of a TEM
2. the basics of electron optics and image formation
3. the basics of electron beam – sample interactions
4. the contrast mechanism
5. various sample preparation techniques

Learning how to
1. align and operate a TEM
2. acquire data using different operation modes of a TEM instrument, i.e. Bright-field and Dark-field imaging
3. record electron diffraction patterns and index diffraction patterns
4. interpret TEM data
A successful participant of the course is able to:

- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- build and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of exteriors and contingent valuation; the economics of non-renewable resources, renewable resources, environmental cost-benefit analysis, sustainability concepts and market failure; external effects, public goods, and environmental policy; the measurement of exteriors and contingent valuation; the economics of non-renewable resources, renewable resources, environmental cost-benefit analysis, sustainability concepts; international environmental economic theory and policy at international level, e.g. to the problem of climate change.

Implementing solutions: project management, critical path method, quality control feedback loop.

Practical:
- Demo, practical demonstration of a TEM: instrument components, alignment, etc.
- Hands-on training for students: sample loading, instrument alignment and data acquisition.
- Sample preparation for different types of materials
- Practical work with TEMs
- Demonstration of advanced Transmission Electron Microscopy techniques

Prerequisites / notice
No mandatory prerequisites. Please consider the prior attendance to EM Basic lectures (551-1618-00V; 227-0390-00L; 327-0703-00L) as suggested prerequisite.
The course is for advanced students and introduces and discusses the theoretical foundations of solid-state nuclear magnetic resonance.

Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course starts with a recapitulation of density operator and product operator formalism with special emphasis on electron-nuclear spin systems in the solid state. We then treat basic phenomena, such as passage effects, avoided level crossings, and hyperfine decoupling. Based on these foundations, we discuss polarization transfer from the electron to the nuclear spin and back, as well as spin diffusion as a mechanism for polarizing nuclear spins beyond the immediate vicinity of the electron spin. The second half of the course will cover dynamic nuclear polarization (DNP), with a focus on instrumentation required to perform DNP with magic angle spinning (MAS) NMR. An introduction to statistical mechanics and thermodynamics. Prediction of thermodynamic and kinetic properties from molecular data. Basics of statistical mechanics and thermodynamics of classical and quantum systems. Concept of ensembles, microcanonical and canonical ensembles, ergodic theorem. Molecular and canonical distribution functions and their connection to macroscopic thermodynamics. Quantum statistics, Translational, rotational, vibrational, electronic and nuclear spin partition functions of gases. Determination of the equilibrium constants and (transition-state theory) rates of gas phase reactions. Description of ideal gases and ideal crystals. Lattice models, mixing entropy of polymers, and entropic elasticity. The course will motivate discussions of technology development. Specific technologies to be covered include, but are not limited to, frequency agile gyrotron oscillators, corrugated waveguides, microwave lenses, strategies for creating pulsed and frequency chirped microwaves, spherical MAS rotors and supporting stators, high temperature superconductor (HTS) based compact magnets, and radio-frequency building blocks allow a tailoring of the effective Hamiltonian to the needs of the experiment. These basic building blocks can then be combined in different ways to obtain spectra that contain the desired information.

Prerequisites / notice
A script which covers the topics will be distributed in the lecture and will be accessible through the course Moodle.

Lecture notes

Prerequisites / notice
A script which covers the topics will be distributed in the lecture and will be accessible through the web page http://www.phys.ethz.ch/education/

Lecture notes

Prerequisites / notice
Prequisite: A basic knowledge of Magnetic Resonance, e.g. as covered in the Lecture Physical Chemistry IV, or the book "Spin Dynamics" by Malcolm Levitt.

Lecture notes
The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

Prerequisites / notice
Prequisite: A basic knowledge of NMR, e.g. as covered in the Lecture Physical Chemistry IV, or the book "Spin Dynamics" by Malcolm Levitt.
Fostered competencies | Subject-specific Competencies | Concepts and Theories | assessed
---|---|---|---
Method-specific Competencies | Analytical Competencies | assessed
Social Competencies | Communication | not assessed
Personal Competencies | Creative Thinking | assessed
Critical Thinking | assessed

701-1253-00L | Analysis of Climate and Weather Data | W | 3 credits | 2G | C. Frei

Abstract
An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.

Objective
Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses. The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.

Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.

The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.

R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

Lecture notes
Documentation and supporting material:
- slides used during the lecture
- exercise sets and solutions
- R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

Literature
For complementary reading:

Prerequisites / notice
Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.

701-1257-00L | European Climate Change | W | 3 credits | 2G | C. Schär, J. Rajcyczak, S. C. Scherrer

Abstract
The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:
- observational datasets, observation and detection of climate change;
- underlying physical processes and feedbacks;
- numerical and statistical approaches;
- currently available projections.

Objective
At the end of this course, participants should:
- understand the key physical processes shaping climate change in Europe;
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
- be familiar with relevant observational and modeling data sets;
- be able to tackle simple climate change questions using available data sets.

Content
Contents:
- global context
- observational data sets, analysis of climate trends and climate variability in Europe
- global and regional climate modeling
- statistical downscaling
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
- projections of European and Alpine climate change

Lecture notes
Slides and lecture notes will be made available at http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html

Prerequisites / notice
Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

Proseminars and Semester Papers
To organise a semester project take contact with one of the instructors.

Not all lecturers are directly eligible in myStudies if “Professors” is the required type of lecturers. In such cases please take contact with the Study Administration (www.phys.ethz.ch/studies/study-administration.html).

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<td>402-0210-MSL</td>
<td>Proseminar Theoretical Physics</td>
<td>W</td>
<td>8 credits</td>
<td>4S</td>
<td>Supervisors</td>
</tr>
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</table>

Abstract
A guided self-study of original papers and of advanced textbooks in theoretical physics. Within the general topic, determined each semester, participants give a presentation on a particular subject and deliver a written report.

Objective
The goals of the proseminar are four-fold:
- to expand your knowledge of theoretical physics;
- to learn how to give a professional presentation;
- to learn how to write a scientific report; and
- to take part in scientific discussions.

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<th>Number</th>
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<tr>
<td>402-0217-MSL</td>
<td>Semester Project in Theoretical Physics</td>
<td>W</td>
<td>8 credits</td>
<td>15A</td>
<td>Supervisors</td>
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</table>

Abstract
This course unit is an alternative if no suitable “Proseminar Theoretical Physics” is available of if the proseminar is already overbooked.
The goals of the proseminar are four-fold:
i) to expand your knowledge of theoretical physics;
ii) to learn how to give a professional presentation;
iii) to learn how to write a scientific report; and
(iv) to take part in scientific discussions.

Die Leistungskontrolle erfolgt aufgrund eines oder mehrerer schriftlicher Berichte bzw. einer schriftlichen Arbeit. Vorträge können ein zusätzlicher Bestandteil der Leistungskontrolle sein.

**402-0215-MSL**

**Objective**
The aim of the project is to give the student experience in working in a research environment, carrying out physics experiments, analysing and interpreting the resulting data.

**Objective**
- conduct a project in a research laboratory,
- discuss their experimental results and conclusions in a team,
- present their experimental findings in written and oral form.

**Prerequisites / notice**

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**402-0740-00L**

**Abstract**
The Standard Model of particle physics is a monumental achievement of human ingenuity. While typically approached from the theoretical side, in this proseminar we will collect the experimental evidence upon which the Standard Model has been built.

**Objective**
This course integrates knowledge of all detector components (tracking, calorimetry, trigger) in discussing the experiments as a whole. It is meant to be complementary to the "Experimental Methods" course 402-0725-00L which introduces different detector technologies. It also augments the particle physics master curriculum and is meant to be followed in parallel to PPP I (402-0891-00L) or PPP II (402-0702-00L).

**Content**
The course will not follow the historical trajectory of experimental particle physics. It will instead try to give a modern view of the results of the experiments and show where they fit in the theoretical construction.

The students will read the original papers collected in the seminal text by Cahn and Goldhaber. The theory will be distilled to the very basics using the textbook by Bettini.

**Literature**
Cahn, Goldhaber "Experimental Foundations of Particle Physics" (2nd edition), Cambridge University Press
Bettini, "Introduction to Elementary Particle Physics" Cambridge University Press

**Prerequisites / notice**
Recommended: Phenomenology of Particle Physics I (or II) (in parallel)

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**402-0717-MSL**

**Objective**
During the semester break participating students stay for 4 weeks at CERN and perform experimental work relevant to our particle physics projects. Dates to be agreed upon.

**Content**
Detailed information in: https://etetheilchenpraktikumn.web.cern.ch/

**Prerequisites / notice**
Language of instruction: English or German

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**402-0719-MSL**

**Objective**
During the semester breaks 6-12 students stay for 3 weeks at PSI and participate in a hands-on course on experimental particle physics. A small real experiment is performed in common, including apparatus design, construction, running and data analysis. The course includes some lectures, but the focus lies on the practical aspects of experimenting.

**Objective**
Students learn all the different steps it takes to perform a complete particle physics experiment in a small team. They acquire skills to do this themselves in the team, including design, construction, data taking and data analysis.

**Prerequisites / notice**
In agreement with the lecturers a semester paper in the context of the topics discussed in the lectures can be written.

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**402-0340-MSL**

**Abstract**

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**Science in Perspective**

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Reflection Capability

Recommended Science in Perspective (Type B) for D-PHYS

see Science in Perspective: Language Courses ETH/ UZH

### Master's Thesis

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<tr>
<th>Number</th>
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<td>O</td>
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<td>D. Kienzler</td>
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<td>Target audience:</td>
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<td>Master students who cannot document to have received an adequate training in working scientifically.</td>
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<td>Abstract</td>
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<tr>
<td></td>
<td>Literature Review: ETH-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX; Mathematical Writing; AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.</td>
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<td>Objective</td>
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<td>Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.</td>
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<td>Only students who fulfil the following criteria are allowed to begin with their master's thesis:</td>
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<td>a. successful completion of the bachelor programme;</td>
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<td>b. fulfilling of any additional requirements necessary to gain admission to the master programme.</td>
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<td>c. have acquired at least 8 credits in the category Proseminars and Semester Papers.</td>
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<td>Further information:</td>
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<td><a href="http://www.phys.ethz.ch/phys/education/master/msc-theses">http://www.phys.ethz.ch/phys/education/master/msc-theses</a></td>
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<td>The master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.</td>
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### Seminars, Colloquia, and Additional Courses

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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0101-00L</td>
<td>The Zurich Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>S. Huber, A. Refregier, University lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Research colloquium</td>
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</tr>
<tr>
<td>Objective</td>
<td>The goal of this event is to bring you closer to current day research in all fields of physics. In each semester we have a set of distinguished speakers covering the full range of topics in physics. As a participating student should learn how to follow a research talk. In particular, you should be able to extract key points from a colloquium where you don't necessarily understand every detail that is presented.</td>
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<tr>
<td>402-0800-00L</td>
<td>The Zurich Theoretical Physics Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>J. Renes, University lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Research colloquium</td>
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</tr>
<tr>
<td>Objective</td>
<td>The Zurich Theoretical Physics Colloquium is jointly organized by the University of Zurich and ETH Zurich. Its mission is to bring both students and faculty with diverse interests in theoretical physics together. Leading experts explain the basic questions in their field of research and communicate the fascination for their work.</td>
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<tr>
<td>401-5330-00L</td>
<td>Talks in Mathematical Physics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>A. Cattaneo, G. Folder, M. Gaberdiel, G. M. Graf, P. Hintz, T. H. Willwacher</td>
</tr>
<tr>
<td>Abstract</td>
<td>Research colloquium</td>
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<td></td>
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<tr>
<td>Abstract</td>
<td>Research colloquium</td>
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<tr>
<td>402-0600-00L</td>
<td>Nuclear and Particle Physics with Applications</td>
<td>E-</td>
<td>0 credits</td>
<td>2S</td>
<td>A. Rubbia, K. S. Kirch</td>
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<tr>
<td>402-0893-00L</td>
<td>Particle Physics Seminar</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>T. K. Gehrmann</td>
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<tr>
<td>Abstract</td>
<td>Research colloquium</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Occasionally, talks may be delivered in German.</td>
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<tr>
<td>402-0700-00L</td>
<td>Seminar in Elementary Particle Physics</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>M. Spira, University lecturers</td>
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<td>Abstract</td>
<td>Research colloquium</td>
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<tr>
<td>Objective</td>
<td>Stay informed about current research results in elementary particle physics.</td>
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<tr>
<td>402-0746-00L</td>
<td>Seminar: Particle and Astrophysics (Aktuelles aus der Teilchen- und Astrophysik)</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>University lecturers</td>
</tr>
<tr>
<td>Abstract</td>
<td>Research colloquium</td>
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</tr>
<tr>
<td>Content</td>
<td>In Seminarvorträgen werden aktuelle Fragestellungen aus der Teilchenphysik vom theoretischen und experimentellen Standpunkt aus diskutiert. Besonders wichtig erscheint uns der Bezug zu den eigenen Forschungsmöglichkeiten am PSI, CERN und DESY.</td>
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<tr>
<td>402-0300-00L</td>
<td>IPA Colloquium</td>
<td>E-</td>
<td>0 credits</td>
<td>1S</td>
<td>A. Biland, A. de Cosa, A. Refregier, H. M. Schmid, further lecturers</td>
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<tr>
<td>Abstract</td>
<td>Research colloquium</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1922 of 2416
<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Semester</th>
<th>Instructor(s)</th>
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<tr>
<td>402-0396-00L</td>
<td>Recent Research Highlights in Astrophysics (University of Zurich)</td>
<td>E-</td>
<td>0</td>
<td>University lecturers</td>
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<tr>
<td>402-0530-00L</td>
<td>Mesoscopic Systems</td>
<td>E-</td>
<td>0</td>
<td>T. M. Ihn</td>
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<tr>
<td>402-0620-00L</td>
<td>Current Topics in Accelerator Mass Spectrometry and Its Applications</td>
<td>E-</td>
<td>0</td>
<td>M. Christl, S. Willett</td>
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<tr>
<td>227-0980-00L</td>
<td>Seminar on Biomedical Magnetic Resonance</td>
<td>E-</td>
<td>0</td>
<td>K. P. Prüsmann, S. Kozerke, M. Weiger Senften</td>
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<tr>
<td>227-1043-00L</td>
<td>Neuroinformatics - Colloquia (University of Zurich)</td>
<td>E-</td>
<td>0</td>
<td>S.-C. Liu, R. Hahnloser, V. Mante</td>
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<tr>
<td>651-1581-00L</td>
<td>Seminar in Glaciology</td>
<td>E-</td>
<td>3</td>
<td>A. Bauder, M. Jacquemart</td>
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<tr>
<td>402-0010-00L</td>
<td>Basics of Computing Environments for Scientists</td>
<td>Z</td>
<td>0</td>
<td>C. D. Herzog, C. Becker, S. Müller</td>
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</tbody>
</table>

**Abstract**

- **University of Zurich**: No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- **UZH Module Code**: AST006

**Objective**

- **University of Zurich**: No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- **UZH Module Code**: INI701

**Content**

- University of Zurich: Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

**Lecture notes**

- Kryosphäre
- Applied Glaciology
- Physics of Glaciers

**Prerequisites / notice**

Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:

- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

**Fostered competencies**

- Subject-specific Competencies
  - Concepts and Theories
  - Techniques and Technologies
- Method-specific Competencies
  - Analytical Competencies
  - Decision-making
  - Media and Digital Technologies
  - Problem-solving
  - Project Management
- Social Competencies
  - Communication
  - Cooperation and Teamwork
  - Customer Orientation
  - Leadership and Responsibility
  - Self-presentation and Social Influence
  - Sensitivity to Diversity
  - Negotiation
- Personal Competencies
  - Adaptability and Flexibility
  - Creative Thinking
  - Critical Thinking
  - Integrity and Work Ethics
  - Self-awareness and Self-reflection
  - Self-direction and Self-management

**Autumn Semester 2022**
Introduction:
Introduce IT services at D-PHYS and offer modules covering IT-related topics for scientists.

The "IT at D-PHYS" introduction provides a good understanding of how IT works at D-PHYS and presents an overview of the IT services and their providers. It is recommended for everyone joining the department.

The "IT and Information Security" crash course will address the most common threats you'll encounter when using the internet and teach you how to fend them off.

The remainder is structured into individual modules which can be attended separately. They give practical insights into everyday research-related IT challenges.

The "Linux Basics" modules offer an introduction to the Linux landscape and show how to work on the shell by using command line tools. The first part provides a basic understanding of Linux systems and their components. It introduces commands essential to working with local and remote machines. The second part focuses on more advanced tools and workflows and provides guidelines to scripting, automation and customization.

The "Python Ecosystem" modules present various aspects on the ecosystem around Python, without covering the programming language itself. The first part focuses on getting ready to run code. It discusses the management of Python interpreters, packages and virtual environments. The second part presents tools for writing code. From development environments (IDE, Jupyter), over code formatters and linters, to skimming selected concepts (string formatting, regular expressions).

The "System Aspects module" deals with the hardware-related side of scientific computing. To get the best performance out of your scientific code, you have to be aware of the underlying hardware and adapt to it.

Use the dedicated web page https://www.lehrbetrieb.ethz.ch/laborpraktika to register. Enrolled students are eligible for an attestation of attendance after visiting at least 3 out of the 5 modules. Refer to https://compenv.phys.ethz.ch for the detailed contents.

Objective
The exercises involve actual implementation of numerical methods in C++. The course focuses on fundamental ideas and algorithmic aspects of numerical methods.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract

Objective
Develop a physical understanding for static and dynamic phenomena related to (moving) charged objects and understand the structure of the classical field theory of electrodynamics (transverse versus longitudinal physics, invariances [Lorentz-, gauge-]). Appreciate the interrelation between electric, magnetic, and optical phenomena and the influence of media. Understand a set of classic electrodynamical phenomena and develop the ability to solve simple problems independently. Apply previously learned mathematical concepts (vector analysis, complete systems of functions, Green's functions, co- and contravariant coordinates, etc.). Prepare for quantum mechanics (eigenvalue problems, wave guides and cavities).

Content
Classical field theory of electrodynamics: Derivation and discussion of Maxwell equations, starting from the static limit (electrostatics, magnetostatics, boundary value problems) in the vacuum and in media and subsequent generalization to the full dynamical case (Faraday's law, Ampere/Maxwell law; potentials and gauge invariance). Wave equation and solutions in full space, half-space (Snell's law), waveguides, cavities, generation of electromagnetic radiation, scattering and diffraction of light (optics). Application to various specific examples. Discussion of the structure of Maxwell's equations, Lorentz invariance, relativity theory and covariance, Lagrangian formulation. Dynamics of relativistic particles in the presence of fields and their radiation properties (synchrotron).

Literature
J.D. Jackson, Classical Electrodynamics
W.K.H. Panovsky and M. Phillips, Classical electricity and magnetism
A. Sommerfeld, Elektrodynamik, Optik (Vorlesungen über theoretische Physik)
M. Born and E. Wolf, Principles of optics
R. Feynman, R. Leighton, and M. Sands, The Feynman Lectures of Physics, Vol II

Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>406-0204-AAL</td>
<td>Electrodynamics</td>
<td>E-</td>
<td>7 credits</td>
<td>15R</td>
<td>J. Brödel</td>
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<tr>
<td>401-2673-AAL</td>
<td>Numerical Methods for CSE</td>
<td>E-</td>
<td>9 credits</td>
<td>19R</td>
<td>R. Hiptmair</td>
</tr>
</tbody>
</table>
Objective
* Knowledge of the fundamental algorithms in numerical mathematics
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms
* Ability to choose the appropriate numerical method for concrete problems
* Ability to interpret numerical results
* Ability to implement numerical algorithms efficiently

Content
* Direct Methods for linear systems of equations
* Least Squares Techniques
* Data Interpolation and Fitting
* Filtering Algorithms
* Approximation of Functions
* Numerical Quadrature
* Iterative Methods for non-linear systems of equations

Lecture notes
Lecture materials (PDF documents and codes) will be made available to participants.

Literature


M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

Prerequisites / notice
Solid knowledge about fundamental concepts and techniques from linear algebra & calculus as taught in the first year of science and engineering curricula.

The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves.

### Physics Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
<td>E- Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Dr Suitable for doctorate</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>O Compulsory</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
<th>Eligibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
<td>P practical/laboratory course</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
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</tr>
</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Core

FIN (Finance)

For possible (additional) course offerings see www.msfinance.ch

MF (Mathematical Methods in Finance)

For possible additional course offerings see www.msfinance.ch

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3913-01L</td>
<td>Mathematical Foundations for Finance</td>
<td>W</td>
<td>4</td>
<td>3V+2U</td>
<td>M. Schweizer</td>
</tr>
</tbody>
</table>

Abstract

First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective

This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastics used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest. The main emphasis will be on ideas, but important results will be given with (sometimes partial) proofs.

Content

Topics to be covered include

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
- Black-Scholes formula

Lecture notes

See information on course homepage

Prerequisites / notice

Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly) during the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitslehre").

For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
  - Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
  - Decision-making
  - Problem-solving

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics

FIN (Finance)

For possible additional course offerings see www.msfinance.ch

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-4633-00L</td>
<td>Data Analytics in Organisations and Business</td>
<td>W</td>
<td>5</td>
<td>2V+1U</td>
<td>I. Flückiger</td>
</tr>
</tbody>
</table>

Abstract

This lecture covers organizations and businesses’ end-to-end data analytics process and deepens each process stage. It shows why a stage is needed and what actions are taken in each stage. It gives steps successfully applied in practice and loopholes when issues arise. Case studies from various industries will be presented for each stage.

Objective

This course aims to give the students an understanding of the whole data analytics life cycle in the business world. It shows the expectations of companies and how it is measured. It enables the student to manage successfully all the non-methodological aspects of a data analytics project which are the primary source of failure in end-to-end executions. The student will become familiar with the "business language, and cultural aspects of organizations. It also gives an overview of the data analytics tool, platform, and methods ecosystem for successfully technical data analyses.

Content

1) Introduction
2) Framing the business problem
3) Framing the analytics problem
4) Data
5) Identification of problem-solving approaches and appropriate tools
6) How to set up and validate models
7) The deployment of a model
8) Model lifecycle
9) Operating models and roles
10) Some words about soft skills needed by statistical and mathematical professionals

Lecture notes

The lecture's presentation slides will be provided.

Prerequisites / notice

Prerequisites: Basic statistics and probability theory and regression

MF (Mathematical Methods in Finance)

For possible additional course offerings see www.msfinance.ch

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>363-1081-00L</td>
<td>Asset Liability Management and Treasury Risks</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>P. Mangold, M. Eichhorn</td>
</tr>
</tbody>
</table>

Abstract

Asset Liability Management (ALM) is key to the financial success of any corporation. The goal is to develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and related profits and losses, including identification and mitigation of undue risks taken. This course is geared towards preparing students to apply these concepts in practical settings.
Objective
The main learning objectives of this course are:
- develop a comprehensive understanding of the nature of corporate balance sheet and off-balance sheet positions and their respective contribution to profits and losses
- measure and assess exposures to risk factors such as interest and FX rates, equity and commodity prices, as well as liquidity events
- trading and hedging to mitigate undue risks incurred

Content
The course is organized around a series of case studies. We will first discuss and develop an understanding of the fundamentals on different aspects of the management and risk management of the balance sheet. Using real life case studies each concept will then be directly applied and tested. In-class discussions, presentations and one written assignment are used to facilitate active and interactive learning in a stimulating environment. During the case studies students will frequently work in small groups. Therefore, the number of participants is limited to 40.

The course focuses on the application of finance concepts to the financial management of corporations and is geared towards preparing students to apply these concepts in practical settings. Executives of all sectors are expected to have a sound understanding of the content covered. As such, the course is not exclusively targeted at students who are considering a career in the financial services sector. It also recommended for students who want to work in the finance, treasury or risk area of corporates. It is also suitable for students who want to work for a consultancy firm.

Literature
No single textbook covers the course, below we list some useful references. Further materials will be made available to students prior to the lectures


Prerequisites / notice
Participants should have a basic understanding of financial management, gained, for example, from prior undergraduate economics, business, or accounting studies.

MF (Mathematical Methods in Finance)
For possible additional course offerings see www.msfinance.ch
This is an advanced course on mathematical finance for students with a good background in probability. We want to give an overview of main concepts, questions and approaches, and we do this mostly in continuous-time models.

Topics include:
- semimartingales and general stochastic integration
- absence of arbitrage and martingale measures
- fundamental theorem of asset pricing
- option pricing and hedging
- hedging duality
- optimal investment problems
- and probably others

Lecture notes

The course is based on different parts from different books as well as on original research literature.

Literature

The course is based on different parts from different books as well as on original research literature. Lecture notes will not be available.

Prerequisites / notice

Prerequisites are the standard courses
- Probability Theory (for which lecture notes are available)
- Brownian Motion and Stochastic Calculus (for which lecture notes are available)

Those students who already attended "Introduction to Mathematical Finance" will have an advantage in terms of ideas and concepts.

This course is the second of a sequence of two courses on mathematical finance. The first course "Introduction to Mathematical Finance" (MF I), 401-3888-00, focuses on models in finite discrete time. It is advisable that the course MF I is taken prior to the present course, MF II.

For an overview of courses offered in the area of mathematical finance, see https://www.math.ethz.ch/imsf/education/education-in-stochastic-finance/overview-of-courses.html.

401-4657-00L Numerical Solution of Stochastic Ordinary Differential Equations W 6 credits 3V+1U A. Stein

Abstract

This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective

The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content

Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes

There will be English, typed lecture notes for registered participants in the course.

Literature


Prerequisites / notice

Prerequisites:
- Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.

a) mandatory courses:
Elementary Probability,
Probability Theory I.

b) recommended courses:
Stochastic Processes.

Start of lectures: Wednesday September 21, 2022.

401-3929-00L Financial Risk Management in Social and Pension Insurance W 4 credits 2V P. Blum

Abstract

Investment returns are an important source of funding for social and pension insurance, and financial risk is an important threat to stability. We study short-term and long-term financial risk and its interplay with other risk factors, and we develop methods for the measurement and management of financial risk and return in an asset/liability context with the goal of assuring sustainable funding.
Understand the basic asset-liability framework: essential principles and properties of social and pension insurance; cash flow matching, duration matching, valuation portfolio and loose coupling; the notion of financial risk; long-term vs. short-term risk; coherent measures of risk.

Understand the conditions for sustainable funding: derivation of required returns; interplay between return levels, contribution levels and other parameters; influence of guaranteed benefits.

Understand the notion of risk-taking capability: capital process as a random walk; measures of long-term risk and relation to capital; short-term solvency vs. long-term stability; effect of embedded options and guarantees; interplay between required return and risk-taking capability.

Be able to study empirical properties of financial assets: the Normal hypothesis and the deviations from it; statistical tools for investigating relevant risk and return properties of financial assets; time aggregation properties; be able to conduct analysis of real data for the most important asset classes.

Understand and be able to carry out portfolio construction: the concept of diversification; limitations to diversification; correlation breakdown; incorporation of constraints; sensitivities and shortcomings of optimized portfolios.

Understand and interpret the asset-liability interplay: the optimized portfolio in the asset-liability framework; short-term risk vs. long-term risk; the influence of constraints; feasible and non-feasible solutions; practical considerations.

Understand and be able to address essential problems in asset / liability management, e.g. optimal risk / return positioning, optimal discount rate, target value for funding ratio or turnaround issues.

Have an overall view: see the big picture of what asset returns can and cannot contribute to social security; be aware of the most relevant outcomes; know the role of the actuary in the financial risk management process.

Risk and return of financial assets cannot be separated from one another and, hence, asset management and risk management cannot be separated either. Managing financial risk in social and pension insurance is, therefore, the task of reconciling the contradictory dimensions of

1. Required return for a sustainable funding of the institution,
2. Risk-taking capability of the institution,
3. Returns available from financial assets in the market,
4. Risks incurred by investing in these assets.

This task must be accomplished under a number of constraints. Financial risk management in social insurance also means reconciling the long time horizon of the promised insurance benefits with the short time horizon of financial markets and financial risk.

It is not the goal of this lecture to provide the students with any cookbook recipes that can readily be applied without further reflection. The goal is rather to enable the students to develop their own understanding of the problems and possible solutions associated with the management of financial risks in social and pension insurance.

To this end, a rigorous intellectual framework will be developed and a powerful set of mathematical tools from the fields of actuarial mathematics and quantitative risk management will be applied. When analyzing the properties of financial assets, an empirical viewpoint will be taken using statistical tools and considering real-world data.

Extensive handouts will be provided. Moreover, practical examples and data sets in Excel will be made available.

Solid base knowledge of probability and statistics is indispensable. Specialized concepts from financial and insurance mathematics as well as quantitative risk management will be introduced in the lecture as needed, but some prior knowledge in some of these areas would be an advantage.

This course counts towards the diploma of "Aktuar SAV".

The exams ONLY take place during the official ETH examination period.

401-3922-00L Life Insurance Mathematics W 4 credits 2V M. Koller

Abstract
The classical life insurance model is presented together with the important insurance types (insurance on one and two lives, term and endowment insurance and disability). Besides that the most important terms such as mathematical reserves are introduced and calculated. The profit and loss account and the balance sheet of a life insurance company is explained and illustrated.

401-3928-00L Reinsurance Analytics W 4 credits 2V

Abstract
Does not take place this semester.

This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and models for extreme events such as natural or man-made catastrophes. The lecture covers reinsurance contracts, experience and exposure pricing, natural catastrophe modelling, solvency regulation, and insurance linked securities.

Objective
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes. Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds
This course provides an introduction to reinsurance from an actuarial perspective. The objective is to understand the fundamentals of risk transfer through reinsurance and the mathematical approaches associated with low frequency high severity events such as natural or man-made catastrophes. Topics covered include:
- Reinsurance Contracts and Markets: Different forms of reinsurance, their mathematical representation, history of reinsurance, and lines of business.
- Experience Pricing: Modelling of low frequency high severity losses based on historical data, and analytical tools to describe and understand these models.
- Exposure Pricing: Loss modelling based on exposure or risk profile information, for both property and casualty risks.
- Natural Catastrophe Modelling: History, relevance, structure, and analytical tools used to model natural catastrophes in an insurance context.
- Solvency Regulation: Regulatory capital requirements in relation to risks, effects of reinsurance thereon, and differences between the Swiss Solvency Test and Solvency 2.
- Insurance linked securities: Alternative risk transfer techniques such as catastrophe bonds.

Lecture notes
Slides and lecture notes will be made available.

Prerequisites / notice
Basic knowledge in statistics, probability theory, and actuarial techniques.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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<table>
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<tr>
<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<tr>
<td></td>
<td>Project Management</td>
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| Social Competencies | Communication | assessed |
|                    | Cooperation and Teamwork | not assessed |
|                    | Customer Orientation     | not assessed |
|                    | Leadership and Responsibility | not assessed |
|                    | Self-presentation and Social Influence | not assessed |
|                    | Sensitivity to Diversity | not assessed |
|                    | Negotiation             | not assessed |

| Personal Competencies | Adaptability and Flexibility | assessed |
|                      | Creative Thinking          | not assessed |
|                      | Critical Thinking          | not assessed |
|                      | Integrity and Work Ethics  | not assessed |
|                      | Self-awareness and Self-reflection | not assessed |
|                      | Self-direction and Self-management | not assessed |

401-3931-00L Responsible Machine Learning with Insurance Applications

Abstract
This lecture covers important aspects of applying supervised machine learning models in a responsible way, based on sound statistical theory. The focus is on model interpretability, calibration (bias) assessment, and proper model comparison. The methods are illustrated with actuarial datasets.

Objective
The student is familiar with the main tools of model interpretability, calibration assessment, and model comparison and knows how to apply supervised machine learning in a responsible way.

Content
- Overview of supervised machine learning (statistical learning theory, GLMs, tree based methods, and neural nets; cross-validation)
- Model interpretability methods (partial dependence plots, measures of variable importance, and SHAP)
- Bias/calibration assessment with identification functions
- Model comparison with consistent scoring functions
- Working with dependent observations and further topics

Prerequisites / notice
This course will be held in English and counts towards the diploma of "Aktuar SAV". For the latter, see details under www.actuaries.ch.

Prerequisites: Good knowledge in statistics/probability theory, statistical modelling and the R programming language are assumed.

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Master's Thesis
see www.oec.uzh.ch/studies/general/theses/oec_en.html

Quantitative Finance Master - Key for Type

<table>
<thead>
<tr>
<th>Q</th>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Quantum Engineering Master

Core Courses

A minimum of 24 credits must be obtained from core courses during the MSc QE course selection is subject to the tutor's agreement.

Quantum Technology Lab

This core course is a prerequisite for participation in the QuanTech Labs of the second and third semester.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

In this course students will be exposed to different topics of quantum engineering and develop ideas for possible projects. Based on presentations by ETH labs participating in the MSc QE program and with the assistance of a mentor students will work in groups to develop concrete plans for a quantum experiment.

Objective

Acquire a broad overview of quantum engineering activities at ETH and develop own ideas about future quantum engineering projects.

Engineering Core Courses

These core courses target students with a physics background and all those who need additional engineering foundations.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6 credits</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
</tbody>
</table>

Abstract

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Objective

Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content


Literature


Prerequisites / notice

Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-0116-00L</td>
<td>VLSI 1: HDL Based Design for FPGAs</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>F. K. Gürkaynak, L. Benini</td>
</tr>
</tbody>
</table>

Abstract

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

Objective

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog.
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Aneucau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

Lecture notes

Textbook and all further documents in English.

Literature


Prerequisites / notice

Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://ilis-students.ee.ethz.ch/lectures/vlsi-i/
Analog Integrated Circuits

This course provides a foundation in analog integrated circuit design based on bipolar and CMOS technologies. Integrated circuits are responsible for much of the progress in electronics in the last 50 years, particularly the revolutions in the Information and Communications Technologies we witnessed in recent years. Analog integrated circuits play a crucial part in the highly integrated systems that power the popular electronic devices we use daily. Understanding their design is beneficial to both future designers and users of such systems.

The basic elements, design issues and techniques for analog integrated circuits will be taught in this course.

Content
Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors.

The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes
Hands out of presented slides. No script but an accompanying textbook is recommended.

Literature

Optical Communication Fundamentals

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

Content
* Chapter 1: Introduction: Analog/Digital conversion, The communication channel, Shannon channel capacity, Capacity requirements.


* Chapter 4: The Receiver: Photodiodes, Receiver noise, Detector schemes (direct detection, coherent detection), Bit-error ratios and error estimations.

* Chapter 5: Digital Signal Processing Techniques: Digital signal processing in a coherent receiver, Error detection teqchniques, Error correction coding.

* Chapter 6: Pulse Shaping and Multiplexing Techniques: WDM/FDM, TDM, OFDM, Nyquist Multiplexing, OCDMA.

* Chapter 7: Optical Amplifiers: Semiconductor Optical Amplifiers, Erbium Doped Fiber Amplifiers, Raman Amplifiers.

Lecture notes
Lecture notes are handed out.

Literature
Govind P. Agrawal; "Fiber-Optic Communication Systems"; Wiley, 2010

Prerequisites / notice

Information Theory I

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equipartition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

Content
The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

The entropy rate of a source, Typical sequences, the asymptotic equipartition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the channel coding theorem, the source-channel separation theorem, feedback capacity

Literature
T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

Physics Core Courses

These core courses target students with an engineering background and all those who need additional physics foundations.

Number Title Type ECTS Hours Lecturers
402-0205-00L Quantum Mechanics I W 10 credits 3V+2U C. Anastasiou

Abstract

Objective
Applications: simple potentials in wave mechanics, scattering and resonance, harmonic oscillator, hydrogen atom, and perturbation theory.

Content
Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.

The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradoxon and Bell's inequality); Perturbation theory.

Lecture notes
Auf Moodle

Literature
G. Baym, Lectures on Quantum Mechanics
E. Merzbacher, Quantum Mechanics
L.I. Schiff, Quantum Mechanics
R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals
J.J. Sakurai: Modern Quantum Mechanics
A. Messiah: Quantum Mechanics I
S. Weinberg: Lectures on Quantum Mechanics
Introduction to Solid State Physics

W 10 credits 3V+2U C. Degen

Abstract
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, electronic properties of insulators, metals, semiconductors, transport properties, magnetism, superconductivity.

Objective
Introduction to Solid State Physics.

Content
The course provides an introduction to solid state physics, covering several topics that are later discussed in more detail in other more specialized lectures. The central topics are: solids and their lattice structures; interatomic bindings; lattice dynamics, thermal properties of insulators; metals (classical and quantum mechanical description of electronic states, thermal and transport properties of metals); semiconductors (bandstructure and n/p-type doping); magnetism, superconductivity.

Lecture notes
Ibach & Lüth, Festkörperphysik
C. Kittel, Festkörperphysik
Ashcroft & Mermin, Festkörperphysik
W. Känzig, Kondensierte Materie

Prerequisites
Voraussetzungen: Physik I, II, III wünschenswert

Quantum Physics for Non-Physicists

W 6 credits 3V+2U P. Kammerlander

Abstract
This is an introduction to the physics of quantum mechanics, aimed primarily at students with little to no background in physics. We start from the basic postulates and follow an information-theoretical approach to study the behaviour of quantum systems, from a single spin to entangled particles in space and the hydrogen atom.

Objective
This course teaches the basics of quantum physics, and complements courses in quantum computation and information theory. Students are equipped with tools to tackle complex quantum mechanical problems and foundational questions. The course covers approximately the same content as QM1, but from an information-driven perspective.

Content
Quantum formalism, from qubits to particles in space; Time and dynamics for quantum systems; Problems in 1D; Uncertainty and open systems; Spin; Problems in 3D; Non-locality and foundational aspects of quantum theory.

Lecture notes
Lecture notes will be distributed through the semester.

Literature
Quantum Processes Systems, and Information, by Benjamin Schumacher and Michael Westmoreland, available at
https://www.cambridge.org/core/books/quantum-processes-systems-and-information/4E459E64E1EE7121CA2321435FAECC8A

Prerequisites
Basic linear algebra and calculus knowledge is required (equivalent to first-year courses). Physics knowledge is not required. Physicists and students from a different background than outlined above are welcome at their own risk.

Note that while we follow an information-theoretical approach, this is not a course on quantum information theory or quantum computing. It therefore complements those courses offered at ETH in both semesters.
### 402-0442-00L Quantum Optics

<table>
<thead>
<tr>
<th>W</th>
<th>10 credits</th>
<th>3V+2U</th>
<th>A. Imamoglu</th>
</tr>
</thead>
</table>

**Abstract**
This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics covered include the quantum nature of light, semi-classical and quantum mechanical description of light-matter interaction, laser manipulation of atoms and ions, optomechanics and quantum computation.

**Objective**
The course aims to provide the knowledge necessary for pursuing research in the field of Quantum Optics. Fundamental concepts and techniques of Quantum Optics will be linked to modern experimental research. During the course the students should acquire the capability to understand currently published research in the field.

**Content**
This course gives an introduction to the fundamental concepts of Quantum Optics and will highlight state-of-the-art developments in this rapidly evolving discipline. The topics that are covered include:
- coherence properties of light
- quantum nature of light: statistics and non-classical states of light
- light matter interaction: density matrix formalism and Bloch equations
- quantum description of light matter interaction: the Jaynes-Cummings model, photon blockade
- laser manipulation of atoms and ions: laser cooling and trapping, atom interferometry,
- further topics: Rydberg atoms, optomechanics, quantum computing, complex quantum systems.

**Lecture notes**
Selected book chapters will be distributed.

**Literature**
Text-books:
- G. Gryenberg, A. Aspect and C. Fabre, Introduction to Quantum Physics
- R. Loudon, The Quantum Theory of Light
- Atomic Physics, Christopher J. Foot
- Advances in Atomic Physics, Claude Cohen-Tannoudji and David Guéry-Odelin
- C. Cohen-Tannoudji et al., Atom-Photon-Interactions
- M. Scully and M.S. Zubairy, Quantum Optics
- Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics

### 402-0861-00L Statistical Physics

<table>
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<th>10 credits</th>
<th>4V+2U</th>
<th>E. Demler</th>
</tr>
</thead>
</table>

**Abstract**
This lecture covers the concepts of classical and quantum statistical physics. Several techniques such as second quantization formalism for fermions, bosons, photons and phonons as well as mean field theory and self-consistent field approximation. These are used to discuss phase transitions, critical phenomena and superfluidity.

**Objective**
This lecture gives an introduction in the basic concepts and applications of statistical physics for the general use in physics and, in particular, as a preparation for the theoretical solid state physics education.

**Content**
Kinetic approach to statistical physics: H-theorem, detailed balance and equilibrium conditions.

- Classical statistical physics: microcanonical ensembles, canonical ensembles and grandcanonical ensembles, applications to simple systems.
- Quantum statistical physics: density matrix, ensembles, Fermi gas, Bose gas (Bose-Einstein condensation), photons and phonons.
- Identical quantum particles: many body wave functions, second quantization formalism, equation of motion, correlation functions, selected applications, e.g. Bose-Einstein condensate and coherent state, phonons in elastic media and melting.
- One-dimensional interacting systems.
- Phase transitions: mean field approach to Ising model, Gaussian transformation, Ginzburg-Landau theory (Ginzburg criterion), self-consistent field approach, critical phenomena, Peierls' arguments on long-range order.

**Lecture notes**
Lecture notes available in English.

**Literature**
No specific book is used for the course. Relevant literature will be given in the course.

### 402-0461-00L Quantum Information Theory

<table>
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<th>8 credits</th>
<th>3V+1U</th>
<th>J. Renes</th>
</tr>
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</table>

**Abstract**
The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.

**Objective**
By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.

**Content**
Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

**Lecture notes**
Distributed via moodle.

**Literature**
- Nielsen and Chuang, Quantum Information and Computation
- Preskill, Lecture Notes on Quantum Computation
- Wilde, Quantum Information Theory
- Watrous, The Theory of Quantum Information

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**Electives**

This is a selection of courses particularly suitable for the MSc QE. In agreement with the tutor, students may choose other courses from the ETH course catalogue.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-0101-00L</td>
<td>Discrete-Time and Statistical Signal Processing</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>H.-A. Loeliger</td>
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</table>

**Abstract**
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications: discrete-time linear filters, inverse filters and equalization, DFT, discrete-time stochastic processes, elements of detection theory and estimation theory, LMMSSE estimation and LMMSSE filtering, LMS algorithm, Viterbi algorithm.

**Objective**
The course is about some fundamental topics of digital signal processing with a bias towards applications in communications. The two main themes are linearity and probability. In the first part of the course, we deepen our understanding of discrete-time linear filters. In the second part of the course, we review the basics of probability theory and discrete-time stochastic processes. We then discuss some basic concepts of detection theory and estimation theory, as well as some practical methods including LMMSSE estimation and LMMSSE filtering, the LMS algorithm, and the Viterbi algorithm. A recurrent theme throughout the course is the stable and robust "inversion" of a linear filter.
This course provides a thorough treatment of integrated data conversion systems from system level specifications and trade-offs, over architecture choice down to circuit implementation.

### Content
- Introduction: information representation and communication; abstraction, categorization and symbolic representation; basic conversion algorithms; data converter application; trade-offs among key parameters; ADC taxonomy.
- Dual-slope & successive approximation register (SAR) converters: dual-slope principle & converter; SAR ADC operating principle; SAR implementation with a capacitive array; range extension with segmented array.
- Algorithmic & pipelined A/D converters: algorithmic conversion principle; sample & hold stage; pipeline converter; multiplying DAC; flash sub-ADC and n-bit MDAC; redundancy for correction of non-idealities, error correction.
- Performance metrics and non-linearity: ideal ADC; offset; gain error, differential and integral non-linearities; capacitor mismatch; impact of capacitor mismatch on SAR ADC's performance.
- Flash, folding an interpolating analog-to-digital converters: flash ADC principle, thermometer to binary coding, sparkle correction; limitations of flash converters; the folding principle, residue extraction; folding amplifiers; cascaded folding; interpolation for folding converters; cascaded folding and interpolation.
- Noise in analog-to-digital converters: types of noise; noise calculation in electronic circuit, kT/C-noise, sampled noise; noise analysis in switched-capacitor circuits; aperture time uncertainty and sampling jitter.
- Delta-sigma A/D-converters: linearity and resolution; from delta-modulation to delta-sigma modulation; first-order delta-sigma modulation, circuit level implementation; clock-jitter & SNR in delta-sigma modulators; second-order delta-sigma modulation, higher-order modulation, design procedure for a single-loop modulator.

### Literature
- M. Gustavsson et. al., CMOS Data Converters for Communications, Springer, 2010

### Prerequisites / notice
It is highly recommended to attend the course "Analog Integrated Circuits" of Prof. T. Jang as a preparation for this course.
Content Review of bipolar and MOS devices and their small-signal equivalent circuit models; Building blocks in analog circuits such as current sources, active load, current mirrors, supply independent biasing etc; Amplifiers: differential amplifiers, cascode amplifier, high gain structures, output stages, gain bandwidth product of op-amps; stability; comparators; second-order effects in analog circuits such as mismatch, noise and offset; data converters; frequency synthesizers; switched capacitors. The exercise sessions aim to reinforce the lecture material by well guided step-by-step design tasks. The circuit simulator SPECTRE is used to facilitate the tasks. There is also an experimental session on op-amp measurements.

Lecture notes Handouts of presented slides. No script but an accompanying textbook is recommended.


227-0225-00L Linear System Theory W 6 credits 5G J. Lygeros, A. Tsiamis

Abstract The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Objective Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

Lecture notes Available on the course Moodle platform.

Prerequisites / notice

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>Problem-solving</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
<td>not assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td></td>
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227-0311-00L Qubits, Electrons, Photons W 6 credits 3V+2U T. Zambelli

Abstract In-depth analysis of the quantum mechanics origin of nuclear magnetic resonance (qubits, two-level systems), of LASER (quantization of the electromagnetic field), and of electron transfer (from electrochemistry to photosynthesis).

Objective Beside electronics nanodevices, D-ITET is pushing its research in the fields of NMR (MRI), electrochemistry, bioelectronics, nano-optics, and quantum information, which are all rationalized in terms of quantum mechanics.

Content
- Starting from the axioms of quantum mechanics, we will derive the fascinating theory describing spin and qubits, electron transitions and transfer, photons and LASER: quantum mechanics is different because it mocks our daily Euclidean intuition!

IMPORTANT: “qubits” from the point of view of NMR (and NOT from that of quantum computing!).

- Lagrangian and Hamiltonian: Symmetries and Poisson Brackets
- Postulates of QM: Hilbert Spaces and Operators
- Heisenberg’s Matrix Mechanics: Hamiltonian and Time Evolution Operator
- Density Operator
- Spin: Qubits, Bloch Equations, and NMR
- Entanglement
- Symmetries and Corresponding Operators
- Schrödinger’s Wave Mechanics: Electrons in a Periodic Potential and Energy Bands
- Harmonic Oscillator: Creation and Annihilation Operators
- Identical Particles: Bosons and Fermions
- Quantization of the Electromagnetic Field: Photons, Absorption and Emission, LASER
- Electron Transfer: Marcus Theory via Born-Oppenheimer, Franck-Condon, Landau-Zener

Lecture notes No lecture notes because the proposed textbooks together with the provided supplementary material are more than exhaustive!

Prerequisites / notice

- A solid base of Analysis I & II as well as of Linear Algebra is really helpful.
- The course has been intentionally conceived to be self-consistent with respect to QM for those master students not having encountered it in their track yet. Therefore, a presumably large overlapping has to be expected with a (welcome!) QM introduction course like the D-ITET “Physics II”.

- (as rigorous and profound presentation of the mathematical framework) G. Dell’Antonio, “Lectures on the Mathematics of Quantum Mechanics I”, 2015, Springer

- (as account of those formidable years) G. Gamow, “Thirty Years that Shook Physics”, 1985, Dover Publications Inc.
This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

### Content

At the beginning, signal-flow graphs in general and driving-point signal-flow graphs in particular are introduced. We will use them during the whole term to analyze circuits on a system level (analog continuous-time, analog discrete-time, mixed-signal, and digital) and understand how signals propagate through them. The theory and CMOS implementation of active Filters is then discussed in detail using the example of Gm-C filters and active-RC filters. The ideal and nonideal behaviour of opamps, current conveyors, and inductor simulators follows. The link to the practical design of circuits and systems is done with an overview over different quality measures and figures of merit used in scientific literature and datasheets. Finally, an introduction to discrete-time and mixed-domain filters and circuits is given, including sensor read-out amplifiers, correlated double sampling, and chopping, and an introduction to sigma-delta A/D and D/A conversion on a system level.

This lecture does not go down to the details of transistor implementations. The lecture "227-0166-00L Analog Integrated Circuits" complements this lecture very well in that respect.

### Lecture notes

The base for these lectures are lecture notes and two or three published scientific papers. From these papers we will together develop the technical content.

### Prerequisites / notice

**Prerequisites:**

- Recommended (but not required): Stochastic models and signal processing, Communication Electronics, Analog Integrated Circuits, Transmission Lines and Filters.

- Knowledge of the Laplace transform and z transform and their interpretation (transfer functions, poles and zeros, bode diagrams, stability criteria ...) and of the main properties of linear systems is necessary.

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**227-0468-00L Analog Signal Processing and Filtering**

**W 6 credits 2V+2U H. Schmid**

*Suitable for Master Students as well as Doctoral Students.*

### Abstract

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

### Objective

This lecture provides a wide overview over analog filters (continuous-time and discrete-time), signal-processing systems, and sigma-delta conversion, and gives examples with sensor interfaces and class-D audio drivers. All systems and circuits are treated using a signal-flow view. The lecture is suitable for both analog and digital designers. The way the exam is done allows for the different interests of the two groups.

The learning goal is that the students can apply signal-flow graphs and can understand the signal flow in such circuits and systems (including non-ideal effects) well enough to gain an understanding of further circuits and systems by themselves.

---

**Fostered competencies**

### Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

### Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: assessed

### Social Competencies

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed

### Personal Competencies

- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

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Autumn Semester 2022
The lecture will treat the following chapters:

- Introduction to Dynamic Programming and Optimal Control.

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Mostly the original articles, other useful reading can be found in:

- Strong light-matter coupling in Mid-IR and THz range
- Intersubband absorption and scattering processes
- THz QCLs (direct and non-linear generation)
- Interlevel Qdot transitions and magnetic field effects
- Mid-IR QCLs
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
- Mid-IR QCLs
- Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent taylorbility, this system can be seen as the "ultimate quantum designer's material".

Prerequisites / notice

1. Electrodynamics
2. Physics 1,2
3. Introduction to quantum mechanics

Intersubband Optoelectronics

Abstract

Intersubband transitions in quantum wells are transitions between states created by quantum confinement in ultra-thin layers of semiconductors. Because of its inherent taylorbility, this system can be seen as the "ultimate quantum designer's material".

Objective

The goal of this lecture is to explore both the rich physics as well as the application of these system for sources and detectors. In fact, devices based on intersubband transitions are now unlocking large area of the electromagnetic spectrum.

Content

The lecture will treat the following chapters:

- Introduction: intersubband optoelectronics as an example of quantum engineering
- Technological aspects
- Electronic states in semiconductor quantum wells
- Intersubband absorption and scattering processes
- Mid-IR and THz ISB Detectors
- Mid-infrared and THz photonics: waveguides, resonators, metamaterials
- Quantum Cascade lasers:
- Mid-IR QCLs
- THz QCLs (direct and non-linear generation)
- Further electronic confinement: interlevel Qdot transitions and magnetic field effects
- Strong light-matter coupling in Mid-IR and THz range

Lecture notes

The reference book for the lecture is "Quantum Cascade Lasers" by Jerome Faist, published by Oxford University Press.

Literature

Mostly the original articles, other useful reading can be found in:

- E. Rosencher and B. Vinter, Optoelectronics, Cambridge Univ. Press
- G. Bastard, Wave mechanics applied to semiconductor heterostructures, Halsted press

Prerequisites / notice

Requirements: A basic knowledge of solid-state physics and of quantum electronics.

Nonlinear Optics

Abstract

Nonlinear Optics deals with the interaction of light with matter. I.e. the response of insulators, metals, semiconductors or metamaterials to light and the mathematical framework (classical and quantum mechanical) to describe the phenomena. It is the goal to understand phenomena such as the refractive index, the electro-optic effect, rectification, harmonic generation, FWM, soliton propagation,...

Objective

The important nonlinear optical phenomena are understood and can be classified. The effects can be described mathematical by means of the susceptibility. Participants will be able to design and invent novel photonic, plasmonic or quantum devices.

Content

Chapter 1: The Wave Equations in Nonlinear Optics
Chapter 2: Nonlinear Effects - An Overview
Chapter 3: The Nonlinear Optical Susceptibility - Classical and Quantummechanical Derivations
Chapter 4: Second Harmonic Generation
Chapter 5: The Electro-Optic Effect and the Electro-Optic Modulator
Chapter 6: Acousto-Optic Effect
Chapter 7: Nonlinear Effects of Third Order
Chapter 8: Nonlinear Effects in Media with Gain

Literature

Lecture notes are distributed. For students enrolled in the course, additional information, lecture notes and exercises can be found on moodle (https://moodle-app2.let.ethz.ch/).

Prerequisites / notice

Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics

Nano-Optics

Abstract

Nano-Optics is the study of light-matter interaction at the sub-wavelength scale. It is an flourishing field of fundamental and applied research enabled by the rapid advance of nanotechnology. Nano-optics embraces topics such as plasmonics, optical antennas, optical trapping and manipulation, and high/super-resolution imaging and spectroscopy.

Objective

Understanding concepts of light localization and light-matter interactions on the sub-wavelength scale.

Content

We start with the angular spectrum representation of fields to understand the classical resolution limit. We continue with the theory of strongly focused light, the point spread function, and resolution criteria of conventional microscopy, before turning to super-resolution techniques, based on near- and far-fields. We introduce the local density of states and approaches to control spontaneous emission rates in inhomogeneous environments, including optical antennas. Finally, we touch upon optical forces and their applications in optical tweezers.

Prerequisites / notice

- Electromagnetic fields and waves (or equivalent)
- Physics I+II

Dynamic Programming and Optimal Control

Abstract

Introduction to Dynamic Programming and Optimal Control.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature


Prerequisites / notice

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

Advanced Machine Learning

Abstract

This course provides an introduction to the fundamental concepts of Dynamic Programming and Optimal Control.

Objective

Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content

Introduction to Dynamic Programming and Optimal Control.

Literature

Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Prerequisites / notice

Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.
Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

Fundamentals:
What is data?
Bayesian Learning
Computational learning theory

Supervised learning:
Ensembles: Bagging and Boosting
Max Margin methods
Neural networks

Unsupervised learning:
Dimensionality reduction techniques
Clustering
Mixture Models
Non-parametric density estimation
Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.

Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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252-0836-00L  Computer Science II  W  4 credits  2V+2U  M. Schwerhoff, F. O. Friedrich Wicker

Abstract

The courses covers the foundations of design and analysis of algorithms and data structures, including graph theory and graph problems. It also introduces generic and parallel programming.

Objective

Understanding design, analysis and implementation of fundamental algorithms and data structures. Overview of the concepts of generic and parallel programming. Hands-on experience with implementing the aforementioned in C++.

Content

* Asymptotic runtime (algorithmic complexity)
* Fundamental algorithmic problems, e.g. searching, sorting, shortest paths, spanning trees
* Classical data structures, e.g. search trees, balanced trees, heaps, hash tables
* Graph theory and graph problems
* Problem solving strategies as design patterns for algorithms, e.g. induction, divide and conquer, backtracking, dynamic programming
* Generic programming: C++ templates higher-order functions, lambdas, closures
* Parallel programming: (in)dependence of computations, parallelism and concurrency, shared memory, races, mutual exclusion, communication and synchronisation

Knowledge obtained in the lecture is deepened through practical and/or programming exercises (C++, Code Expert).

Lecture notes

All material (slides, lecture recordings, examples, exercises, etc.) will be published on the course website.

* B. Stroustrup, A Tour of C++, 3rd Edition, Addison-Wesley, 2022

Prerequisites / notice

Prerequisite: Computer Science I

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402-0257-00L  Advanced Solid State Physics  W  10 credits  3V+2U  A. Zheludev

Abstract

This course is an extension of the introductory course on solid state physics.

The purpose of this course is to learn to navigate the complex collective quantum phases, excitations and phase transitions that are the dominant theme in modern solid state physics. The emphasis is on the main concepts and on specific experimental examples, both classic ones and those from recent research.

Objective

The goal is to study how novel phenomena emerge in the solid state.
Content

- Today's challenges and opportunities in Solid State Physics

- Phase transitions and critical phenomena
  - Main concepts: coherence length, symmetry, order parameter, correlation functions, generalized susceptibility
  - Landau theory of phase transitions
  - Fluctuations in Landau theory
  - Critical exponents: significance, measurement, inequalities, equalities
  - Scaling, hyperscaling and universality
  - Quantum phase transitions and quantum criticality

- Fermi surface instabilities
  - The concept of the Landau Fermi liquid in metals
  - Kohn anomalies
  - Charge density waves
  - Metallic ferromagnets and half-metals
  - Spin density waves
  - Superconductivity

- Magnetism of insulators
  - Magnetic interactions in solids and the spin Hamiltonian
  - Magnetic structures and phase transitions
  - Spin waves
  - Quantum magnetism

- Electron correlations in solids
  - Mott insulating state
  - Phases of the Hubbard model

Lecture notes
The printed material for this course involves:
(1) a self-contained script, distributed electronically at semester start.
(2) experimental examples (Power Point slide-style) selected from original publications, distributed at the start of every lecture.

Literature
A list of books will be distributed. Numerous references to useful published scientific papers will be provided.

Prerequisites / notice
This course is for students who like to be engaged in active learning. The "exercise classes" are organized in a non-traditional way:
following the idea of "less is more", we will work on only about half a dozen topics, and this gives students a chance to take a look at
original literature (provided), and to get the grasp of a topic from a broader perspective.

Students report back that this mode of "exercise class" is more satisfying than traditional modes, even if it does not mean less effort.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructors</th>
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<tr>
<td>402-0317-00L</td>
<td>Semiconductor Materials: Fundamentals and Fabrication</td>
<td>W</td>
<td>6 credits</td>
<td>2V+1U</td>
<td>S. Schön, W. Wegscheider</td>
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<tr>
<td>402-0402-00L</td>
<td>Ultrafast Laser Physics</td>
<td>W</td>
<td>10 credits</td>
<td>3V+2U</td>
<td>L. P. Gallmann, S. Johnson, U. Keller</td>
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Abstract

This course gives an introduction into the fundamentals of semiconductor materials. The main focus is on state-of-the-art fabrication and characterization methods. The course will be continued in the spring term with a focus on applications.

Objective

Basic knowledge of semiconductor physics and technology. Application of this knowledge for state-of-the-art semiconductor device processing.

Content

1. Fundamentals of Solid State Physics
   1.1 Semiconductor materials
   1.2 Band structures
   1.3 Carrier statistics in intrinsic and doped semiconductors
   1.4 p-n junctions
   1.5 Low-dimensional structures
2. Bulk Material growth of Semiconductors
   2.1 Czochalski method
   2.2 Floating zone method
   2.3 High pressure synthesis
3. Semiconductor Epitaxy
   3.1 Fundamentals of Epitaxy
   3.2 Molecular Beam Epitaxy (MBE)
   3.3 Metal-Organic Chemical Vapor Deposition (MOCVD)
   3.4 Liquid Phase Epitaxy (LPE)
4. In situ characterization
   4.1 Pressure and temperature
   4.2 Reflectometry
   4.3 Ellipsometry and RAS
   4.4 LEED, AES, XPS
   4.5 STM, AFM
5. The invention of the transistor - Christmas lecture

Lecture notes
https://moodle-app2.let.ethz.ch/course/view.php?id=

Prerequisites / notice
The "compulsory performance element" of this lecture is a short presentation of a research paper complementing the lecture topics. Several topics and corresponding papers will be offered on the moodle page of this lecture.

Abstract

Introduction to ultrafast laser physics with an outlook into cutting edge research topics such as attosecond science and coherent ultrafast sources from THz to X-rays.

Objective

Understanding of basic physics and technology for pursuing research in ultrafast laser science. How are ultrashort laser pulses generated, how do they interact with matter, how can we measure these shortest man-made events and how can we use them to time-resolve ultrafast processes in nature? Fundamental concepts and techniques will be linked to a selection of hot topics in current research and applications.
Content
The lecture covers the following topics:

a) Linear pulse propagation: mathematical description of pulses and their propagation in linear optical systems, effect of dispersion on ultrashort pulses, concepts of pulse carrier and envelope, time-bandwidth product

b) Dispersion compensation: technologies for controlling dispersion, pulse shaping, measurement of dispersion
c) Nonlinear pulse propagation: intensity-dependent refractive index (Kerr effect), self-phase modulation, nonlinear pulse compression, self-focusing, filamentation, nonlinear Schrödinger equation, solitons, non-instantaneous nonlinear effects (Raman/Brillouin), self-steepening, saturable gain and absorption
d) Second-order nonlinearities with ultrashort pulses: phase-matching with short pulses and real beams, quasi-phase matching, second-harmonic and sum-frequency generation, parametric amplification and generation

e) Relaxation oscillations: dynamical behavior of rate equations after perturbation

f) Q-switching: active Q-switching and its theory based on rate equations, active Q-switching technologies, passive Q-switching and theory
g) Active modelocking: introduction to modelocking, frequency comb versus axial modes, theory for various regimes of laser operation, Haus master equation formalism

h) Passive modelocking: slow, fast and ideally fast saturable absorbers, semiconductor saturable absorber mirror (SESAM), designs of and materials for SESAMs, modelocking with slow absorber and dynamic gain saturation, modelocking with ideally fast saturable absorber, Kerr-lens modelocking, soliton modelocking, Q-switching instabilities in modelocked lasers, inverse saturable absorption

i) Pulse duration measurements: rf cables and electronics, fast photodiodes, linear system theory for microwave test systems, intensity and interferometric autocorrelations and their limitations, frequency-resolved optical gating, spectral phase interferometry for direct electric-field reconstruction and more

j) Noise: microwave spectrum analyzer as laser diagnostics, amplitude noise and timing jitter of ultrafast lasers, lock-in detection

k) Ultrafast measurements: pump-probe scheme, transient absorption/differential transmission spectroscopy, four-wave mixing, optical gating and more

l) Frequency combs and carrier-envelope offset phase: measurement and stabilization of carrier-envelope offset phase (CEP), time and frequency domain applications of CEP-stabilized sources

m) High-harmonic generation and attosecond science: non-perturbative nonlinear optics / strong-field phenomena, high-harmonic generation (HHG), phase-matching in HHG, attosecond pulse generation, attosecond technology: detectors and diagnostics, attosecond metrology (streaking, RABBIT, transient absorption, attoclock), example experiments

n) Ultrafast THz science: generation and detection, physics in THz domain, weak-field and strong-field applications

o) Brief introduction to other hot topics: relativistic and ultra-high intensity ultrafast science, ultrafast electron sources, free-electron lasers, etc.

Lecture notes
Class notes will be made available.

Prerequisites / notice
Prerequisites: Basic knowledge of quantum electronics (e.g., 402-0275-00L Quantenelektronik).

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies
assessed
assessed

402-0444-00L Dissipative Quantum Systems
Does not take place this semester.

6 credits
A. Imamoglu

Abstract
This course builds up on the material covered in the Quantum Optics course. The emphasis will be on quantum optics in condensed-matter systems.

Objective
The course aims to provide the knowledge necessary for pursuing advanced research in the field of Quantum Optics in condensed matter systems. Fundamental concepts and techniques of Quantum Optics will be linked to experimental research in systems such as quantum dots, exciton-polaritons, quantum Hall fluids and graphene-like materials.

Content
Description of open quantum systems using master equation and quantum trajectories. Decoherence and quantum measurements. Dicke systems.


Lecture notes
Lecture notes will be provided

Literature
C. Cohen-Tannoudji et al., Atom-Photon-Interactions (recommended)
Y. Yamamoto and A. Imamoglu, Mesoscopic Quantum Optics (recommended)

A collection of review articles (will be pointed out during the lecture)

402-0447-00L Quantum Science with Superconducting Circuits
Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.

Abstract
Superconducting Circuits provide a versatile experimental platform to explore the most intriguing quantum-physical phenomena and constitute one of the prime contenders to build quantum computers. Students will get a thorough introduction to the underlying physical concepts, the experimental setting, and the state-of-the-art of quantum computing in this emerging research field.

Objective
Based on today's most advanced solid state platform for quantum control, the students will learn how to engineer quantum coherent dynamics and how to use them to process quantum information. The students will acquire both analytical and numerical methods to model the properties and phenomena observed in these systems. The course is positioned at the intersection between quantum physics and engineering.

Content

Prerequisites / notice
All students and researchers with a general interest in quantum information science, quantum optics, and quantum engineering are welcome to this course. Basic knowledge of quantum physics is a plus, but not a strict requirement for the successful participation in this course.

402-0457-00L Quantum Technologies for Searches of New Physics

6 credits
2V+1U
P. Crivelli, D. Kienzler
Recent years have witnessed incredible progress in the development of new quantum technologies driven by their application in quantum information, metrology, high precision spectroscopy and quantum sensing. This course will present how these emerging technologies are powerful tools to address open questions of the Standard Model in a complementary way to what is done at the high energy frontier.

The rich physics of the optical properties of semiconductors, as well as the advanced processing available on these materials, enabled G. Scalari, T. Smolenski.

The lecture describes various nanomaterials (semiconductor, metal, dielectric, carbon-based...) for photonic applications (optoelectronics, plasmonics, ordered and disordered structures...). It starts with concepts of light-matter interactions, then the fabrication methods, the optical characterization techniques, the description of the properties and the state-of-the-art applications.

The main part of the course will introduce the following (quantum) technologies and systems, and how they can be used for probing New Physics.

- Cold atoms
- Trapped ions
- Atoms interferometry
- Atomic clocks
- Cold molecules and molecular clocks
- Exotic Atoms
- Anti-matter
- Quantum Sensors

This course requires a good working knowledge in non-relativistic quantum mechanics. Prior knowledge of quantum optics is recommended but not required.
| Content | | |
|---|---|---|---|---|---|
| 1. Introduction to nanomaterials for photonics | a. Classification of nanomaterials | b. Light-matter interaction at the nanoscale | c. Examples of nanophotonic devices | |
| 3. Analogies between photons and electrons | a. Quantum wave description | b. How to confine photons and electrons | c. Tunneling effects | |
| 4. Fabrication of nanomaterials | a. Top-down approach | b. Bottom-up approach | |
| 5. Fabrication of nanomaterials | a. Fabrication of nanomaterials | b. Surface plasmon and localized surface plasmon (sphere, rod, shell) | c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering | d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication | e. Applications |
| 6. Plasmonics | a. What is a plasmon, Drude model | b. Surface plasmon and localized surface plasmon (sphere, rod, shell) | c. Theoretical models to calculate the radiated field: electrostatic approximation and Mie scattering | d. Fabrication of plasmonic structures: Chemical synthesis, Nanofabrication | e. Applications |
| 9. Photonic crystals | a. Analogy photonic and electronic crystal, in nature | b. 1D, 2D, 3D photonic crystal | c. Theoretical modelling: frequency and time domain technique | d. Features: band gap, local enhancement, superprism... | |

Lecture notes:
- Slides and book chapter will be available for downloading
- Lecture notes will be available.

Literature:
- References will be given during the lecture

Prerequisites / notice:
- Basics of solid-state physics (i.e. energy bands) can help

402-0469-67L Parametric Phenomena | W 6 credits | 3G | A. Eichler

Abstract:
There are numerous physical phenomena that rely on time-dependent Hamiltonians (or parametric driving) to amplify, cool, squeeze or couple resonating systems. In this course, we will introduce parametric phenomena in different fields of physics, ranging from classical engineering ideas to devices proposed for quantum neural networks.

Objective:
This course is intended for:
- experimentalists who desire to gain a solid theoretical understanding of nonlinear driven-dissipative systems,
- theorists looking to expand their analytical and numerical toolbox,
- any scientist interested to learn what lies beyond the harmonic resonator.

In the course, the students will grasp the ubiquitous nature of parametric phenomena and apply it to both classical and quantum systems. The students will understand both the theoretical foundations leading to the parametric drive as well as the experimental aspect related to the realizations of the effect. Each student will analyze an independent system using the tools acquired in the course and will present his/her insights to the class.

Content:
This course will provide a general framework for understanding and linking various phenomena, ranging from the child-on-a-swing problem to quantum limited amplifiers, to optical frequency combs, and to optomechanical sensors used in the LIGO experiment. The course will combine theoretical lectures and the study of important experiments through literature.

The students will receive an extended lecture summary as well as numerous MATHEMATICA and Python scripts, including QuTiP notebooks. These tools will enable them to apply analytical and numerical methods to a wide range of systems beyond the duration of the course.

Lecture notes:
- A full script will be available.
### 402-0484-00L Experimental and Theoretical Aspects of Quantum Gases

**Abstract**
Quantum Gases are the most precisely controlled many-body systems in physics. This provides a unique interface between theory and experiment, which allows addressing fundamental concepts and long-standing questions. This course lays the foundation for the understanding of current research in this vibrant field.

**Objective**
The lecture conveys a basic understanding for the current research on quantum gases. Emphasis will be put on the connection between theory and experimental observation. It will enable students to read and understand publications in this field.

**Content**
- Cooling and trapping of neutral atoms
- Bose and Fermi gases
- Ultracold collisions
- The Bose-condensed state
- Elementary excitations
- Vortices
- Superfluidity
- Interference and Correlations

**Lecture notes**
Notes and material accompanying the lecture will be provided.

**Literature**

### 402-0535-00L Introduction to Magnetism

**Abstract**
Atomic paramagnetism and diamagnetism, itinerant and local-moment interatomic coupling, magnetic order at finite temperature, spin precession, approach to equilibrium through thermal and quantum dynamics, dipolar interaction in solids.

**Objective**
- Apply concepts of quantum-mechanics to estimate the strength of atomic magnetic moments and their interactions
- Identify the mechanisms from which exchange interaction originates in solids (itinerant and local-moment magnetism)
- Evaluate the consequences of the interplay between competing interactions and thermal energy
- Apply general concepts of statistical physics to determine the origin of bistability in realistic magnets
- Discriminate the dynamic responses of a magnet to different external stimuli

**Content**
The lecture "Introduction to Magnetism" is a regular course of the Physics MSc program and aims at letting students familiarize themselves with the basic principles of quantum and statistical physics that determine the behavior of real magnets. Understanding why only few materials are magnetic at finite temperature will be the leitmotiv of the course. We will see that defining in a formal way what "being magnetic" means is essential to address this question properly. Theoretical concepts will be applied to few selected nano-sized magnets, which will serve as clean reference systems.

**At the end of this course students should have acquired the basic knowledge needed to develop a research project in the field of magnetism or to attend effectively more advanced courses on this topic.**

- Preliminary contents for the HS21:
  - Magnetism in atoms (quantum-mechanical origin of atomic magnetic moments, intra-atomic exchange interaction)
  - Magnetism in solids (mechanisms producing inter-atomic exchange interaction in solids, crystal field).
  - Spin resonance and relaxation (Larmor precession, resonance phenomena, quantum tunneling, Bloch equation, superparamagnetism)
  - Magnetic order at finite temperatures (Ising and Heisenberg models, low-dimensional magnetism)
  - Dipolar interaction in solids (shape anisotropy, dipolar frustration, origin of magnetic domains)

**Lecture notes**
Learning material will be made available through a dedicated RStudioServer and through Moodle.

**Prerequisites / notice**
Students are assumed to possess a basic background knowledge in quantum mechanics, solid-state and statistical physics as well as classical electromagnetism.

Students will have the opportunity to self-assess their understanding through quizzes and interactive tutorials, mostly inspired by topics of current research in nanoscale magnetism.

### 402-0595-00L Semiconductor Nanostructures

**Abstract**
The course covers the foundations of semiconductor nanostructures, e.g., materials, band structures, bandgap engineering and doping, field-effect transistors. The physics of the quantum Hall effect and of common nanostructures based on two-dimensional electron gases will be discussed, i.e., quantum point contacts, Aharonov-Bohm rings and quantum dots.

**Objective**
At the end of the lecture the student should understand four key phenomena of electron transport in semiconductor nanostructures:
1. The integer quantum Hall effect
2. Conductance quantization in quantum point contacts
3. the Aharonov-Bohm effect
4. Coulomb blockade in quantum dots

**Content**
1. Introduction and overview
2. Semiconductor crystals: Fabrication and molecular beam epitaxy
3. Band structures of semiconductors
4. k-p-theory, effective mass, envelope functions
5. Heterostructures and band engineering, doping
6. Surfaces and metal-semiconductor contacts, fabrication of semiconductor nanostructures
7. Heterostructures and two-dimensional electron gases
8. Drude Transport and scattering mechanisms
9. Single- and bilayer graphene
10. Electron transport in quantum point contacts; Landauer-Büttiker description, ballistic transport experiments
11. Interference effects in Aharonov-Bohm rings
12. Electron in a magnetic field, Shubnikov-de Haas effect
13. Integer quantum Hall effect
14. Coulomb blockade and quantum dots

**Lecture notes**
In addition to the lecture notes, the following supplementary books can be recommended:


The lecture is suitable for all physics students beyond the bachelor of science degree. Basic knowledge of solid state physics is a prerequisite. Very ambitioned students in the third year may be able to follow. The lecture can be chosen as part of the PhD-program. The course is taught in English.

### Fostered competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Media and Digital Technologies: assessed
- Problem-solving: not assessed

#### Social Competencies
- Communication: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed

#### Personal Competencies
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-direction and Self-management: not assessed

### Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-1871-00L</td>
<td>Semester Project</td>
<td>O</td>
<td>12</td>
<td>20A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

Semester projects are designed to train the students for independent scientific work. A project uses the student's technical and social skills acquired during the master's program. The semester project comprises 280 hours of work and is supervised by a professor.

**Objective**

see above

### Internship

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>227-1873-00L</td>
<td>Internship in Industry</td>
<td>W</td>
<td>12</td>
<td></td>
<td>external organisers</td>
</tr>
</tbody>
</table>

**Abstract**

The main objective of the 12-week internship is to expose bachelor's students to the industrial work environment. During this period, students have the opportunity to be involved in on-going projects at the host institution.

**Objective**

see above

### Master’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1800-00L</td>
<td>Master’s Thesis</td>
<td>O</td>
<td>30</td>
<td>68D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

The Master Program finishes with a 6-months Master Thesis which is directed by a Professor of the Department or a Professor of another Department who is associated with the D-ITET. Students gain the ability to conduct independent scientific research on a specific research problem.

**Objective**

see above

### Science in Perspective

see Science in Perspective: Type A: Enhancement of
Reflection Capability

Recommended Science in Perspective (Type B) for D-ITET

see Science in Perspective: Language Courses ETH/UZH

<table>
<thead>
<tr>
<th>Quantum Engineering Master - Key for Type</th>
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<th>Key for Hours</th>
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<tbody>
<tr>
<td>O</td>
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<td>V</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>G</td>
</tr>
<tr>
<td>W</td>
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<tr>
<td></td>
<td></td>
<td>Dr</td>
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</tbody>
</table>

ECTS European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1946 of 2416
## Geospatial Engineering Bachelor

### Basic Courses

#### First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0241-00L</td>
<td>Analysis I</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>M. Akveld, M. Felder</td>
</tr>
<tr>
<td></td>
<td>Abstract: Mathematical tools for the engineer.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Objective: Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers. Mathematical formulation of technical and scientific problems.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Content: Complex numbers. Calculus for functions of one variable with applications. Simple Mathematical models in engineering.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Lecture notes: Wird auf der Vorlesungshomepage zu Verfügung gestellt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urs Stammbach, &quot;Analysis III&quot; (erhältlich im ETH Store); <a href="https://people.math.ethz.ch/~stammbl/analysisskript.html">https://people.math.ethz.ch/~stammbl/analysisskript.html</a></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>401-0141-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5 credits</td>
<td>3V+1U</td>
<td>Akka Ginosar</td>
</tr>
<tr>
<td></td>
<td>Abstract: Introduction to Linear Algebra</td>
<td></td>
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<tr>
<td></td>
<td>Objective: Basic knowledge of linear algebra as a tool for solving engineering problems. Understanding of abstract mathematical formulation of technical and scientific problems. Together with Analysis we develop the basic mathematical knowledge for an engineer. The Modelling competency is taught, applied, and tested, and the Programming competency is applied.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Content: Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces. Calculation with MATLAB will be introduced in the first exercise class.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Lecture notes: The lecturer will provide course notes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
|                 | Literature: K. Nipp, D. Stoffer, Lineare Algebra, VdF Hochschulverlag ETH
|                 | G. Strang, Lineare Algebra, Springer |
| 252-0845-00L    | Computer Science I                   | O    | 5 credits | 2V+2U | Cotrini Jimenez, Fischer |
|                 | Abstract: The course covers the basics concepts of computer programming. |
|                 | Objective: Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs. In the course “Computer Science I”, the competency of programming is taught, applied and examined. Furthermore modeling is taught and applied. |
|                 | Content: variables, types, control structures, functions, scoping, recursion, object-oriented programming. The programming language is Python. |
|                 | Lecture notes: The slides and lecture notes will be made available for download on the course website. |
|                 | Literature: Learn to Code by Solving Problems
|                 | A Python Programming Primer
|                 | Daniel Zingaro
|                 | Python Crash Course
|                 | A Hands-On, Project-Based Introduction to Programming
|                 | Eric Matthes |
| 103-0313-00L    | Spatial Planning and Landscape Development | O    | 5 credits | 4G   | Grét-Regamey, Rät, Van Wezemael |
|                 | Abstract: The lecture introduces into the main-features of spatial planning. Attended will be the subjects planning as a national responsibility, instruments of spatial planning, techniques for problem solving in spatial planning and the Swiss concept for national planning. The lecture is complemented with in-depth mathematical and international examples. |
|                 | Objective: Die Studierenden kennen die Grundzüge der Raumplanung, ihre wichtigsten Instrumente und Problemlösungsverfahren. Sie können das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Übungsaufgaben umsetzen. |
|                 | - Grundzüge der Raumplanung und ihre wichtigsten Instrumente kennenlernen
|                 | - Erarbeiten der Fähigkeit, räumliche Probleme zu erkennen und Problemlösungsverfahren auf diese anzuwenden
|                 | - Planung und Landmanagement als interaktiven Prozess kennenlernen und anwenden
|                 | - Verstehen der mit Fläche und Boden verbundenen Potentiale, Nutzungen und Prozesse
|                 | - Das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Fallbeispielen umsetzen können |
Die Vorlesung deckt die Grundlagen der (Schweizerischen) Raumplanung und Landschaftsentwicklung ab:

- Was ist Raumplanung (Begriffe)
- Prinzipien der Raumplanung
- Die Raumplanung als staatliche Aufgabe - Raumordnungspolitik
- Instrumente der Raumplanung auf den Planungsebenen (u.a. Sachpläne und Konzepte, Richtplanung, Nutzungsplanung, Sondernutzungsplanung, Landumlegungsverfahren)
- Problemlösungsverfahren in der Raumplanung - systemtechnisches Vorgehen
- Das schweizerische Raumordnungskonzept

Der Schwerpunkt der Vorlesung liegt auf der Erläuterung der Raumplanung als Problemlösungsverfahren. Das dabei vermittelte theoretische Wissen wird direkt an einer konkreten, praxisorientierten Übungsaufgabe umgesetzt. Im Rahmen der Übung wird das Projektgebiet während einer Exkursion besucht.

Lecture notes
Prof. Dr. W.A. Schmid et al. (2006, Stand 2017): Raumplanung GZ - Eine Einführung für Ingenieurstudierende. IRL-PLUS, ETHZ

- Handouts of the lectures
- Exercises

Download: http://www.plus.ethz.ch/de/studium/vorlesungen/bsc/spatial_planning_and_landscape_development.html

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**103-0214-00L Cartography Fundamentals**

**Abstract**
Basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics.

**Objective**
Acquire basic knowhow about communication with spatial information by using plans and maps, about the most important design rules and production methods for map graphics. Ability to assess existing products with respect to their content-related and design quality. Ability to design proper plans and well designed legends for basic maps.

**Content**
Definitions "map" and "cartography", map types, current tasks and situation of cartography, map history, spatial reference systems, map projections, map conception and workflow planning, map design, analog and digital map production technology, prepress technology, printing technology, topographic maps, map critics.

**Lecture notes**
Will be distributed module by module.

**Literature**

**Prerequisites / notice**
Further information at http://www.karto.ethz.ch/studium/lehrangebot.html

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories - assessed
- Method-specific Competencies: Analytical Competencies, Media and Digital Technologies, Problem-solving - assessed
- Social Competencies: Customer Orientation, Sensitivity to Diversity - assessed
- Personal Competencies: Creative Thinking, Critical Thinking - assessed

---

**103-0116-00L Ecology and Soil Science**

**Abstract**
The main focus of the lecture are the basics of ecology and soil science. Students learn about the interdependence of organisms and environment, resource cycles, ecosystems as well as soil characteristics and genesis. The impact of human behavior on ecosystems and the problems of different land use are covered by the lecture, too.

**Objective**
- Erlangen eines Einblicks in ökologische Grundlagen
- Fähigkeit, die Folgen planerischen Handelns auf Ökosysteme abzuschätzen
- Verständnis für ökologische Prozesse und Wechselwirkungen
- Funktionen und Potentiale des Bodens verstehen

**Content**
Grundlagen der Ökologie
- Definition von Ökologie, Art, Habitat, Ökosystem, Umwelt
- Einfluss des Menschen auf das Ökosystem
- Zusammenhang von Landschaft und Ökologie
- Ökologische Zusammenhänge für die praktische Anwendung (z.B. in Planungsprozessen)

Grundlagen der Bodenkunde
- Grundbegriffe, Definition von Boden, Bodentypen und wesentliche Kenngrössen
- Bodenwasserhaushalt (Bewässerung, Entwässerung)
- Bodenverdichtung und Erosion
- Bodenrekuilvierung und -renaturierung
- stoffliche Belastungen des Bodens und Sanierungsansätze
- Boden und Raumplanung

**Lecture notes**
Lecture notes and slides (in German) can be downloaded from the PLUS homepage.

Download: https://irl.ethz.ch/de/education/vorlesungen/bsc/ecology_and_soil_science.html

**Literature**

References in the lecture notes

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**Additional Basic Courses**
*No offer in Autumn Semester.*

**Compulsory Courses**

**Examination Block 1**
Analysis III

Abstract
We will model and solve scientific problems with partial differential equations. Differential equations which are important in applications will be classified and solved. Elliptic, parabolic and hyperbolic differential equations will be treated. The following mathematical tools will be introduced: Laplace and Fourier transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Learning to model scientific problems using partial differential equations and developing a good command of the mathematical methods that can be applied to them. Knowing the formulation of important problems in science and engineering with a view toward civil engineering (when possible). Understanding the properties of the different types of partial differential equations arising in science and in engineering.

Content
Classification of partial differential equations

Study of the Heat equation general diffusion/parabolic problems using the following tools through Separation of variables as an introduction to Fourier Series.

Systematic treatment of the complex and real Fourier Series

Study of the wave equation and general hyperbolic problems using Fourier Series, D'Alembert solution and the method of characteristics.

Application of Laplace transform for beam theory will be discussed.

Time permitting, we will introduce the Fourier transform.

Fundamentals of GIS

Abstract
Knowing theoretical aspects of geographic information regarding data acquisition, representation, analysis and visualisation.

Knowing the fundamentals of geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects.

Objective

Content
- Einführung GIS & GIScience
- Konzeptionelles Modell & Datenschema
- Vektorgeometrie & Topologie
- Rastergeometrie und -algebra
- Netzerwe
- Thematische Daten
- Räumliche Statistik
- Systemarchitekturen & Interoperabilität
- Datenqualität, Unsicherheiten & Metadaten
- Räumliche Abfragen und Analysen
- Präsentation raumbezogener Daten
- Geodatenbanken

Lecture notes
Vorlesungspräsentationen werden digital zur Verfügung gestellt.

Literature

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Self-presentation and Social Influence

Personal Competencies
- Creative Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1949 of 2416
Die Satellitengeodäsie beschäftigt sich mit der Bewegung von künstlichen Satelliten unter Einfluss von Störbeschleunigungen und liefert mit den geodätischen Weltraumverfahren präzise Beobachtungen für die Vermessung und Kartierung von Prozessen im System Erde. Dies beinhaltet sowohl die Bestimmung des Schwerefeldes der festen Erde als auch die Kartierung der Meeresoberfläche, etc.

**Objective**
- Sicherheit im Umgang mit Koordinaten-, Referenz- und Zeitsystemen
- Beherrschen der Ephemeridenrechnung für ungestörte und gestörte Satellitenbahnen
- Grundlegendes Verständnis der geodätischen Weltraumverfahren und deren Stärken und Schwächen
- Kenntnis der wichtigsten Prozesse, die für Änderungen in der Geometrie, der Rotation und dem Schwerefeld der Erde verantwortlich sind.
- Erkennen der Anwendungsmöglichkeiten der Space Geodesy für interdisziplinäre Aufgaben (System Erde).

**Content**
- Koordinatensysteme, Transformationen
- Referenz- und Zeitsysteme
- Grundlagen Satellitenbahnen
- Weltraumverfahren: GNSS, VLBI, SLR, DORIS, Altimetrie
- Schwerefeldmissionen
- Kombination der Weltraumverfahren zur Bestimmung der Geometrie, Orientierung sowie des Schwerefeldes der Erde

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<tr>
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<td>not assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

**Lecture notes**
Der Zugang zu den Unterrichtsmaterialien ist über folgenden Link möglich:
https://polybox.ethz.ch/index.php/s/4THAIrTmcMtqMoAFg

**Literature**
Ausgewählte Literatur wird am Anfang der Vorlesung vorgestellt.
Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.

Prerequisites / notice

Fostered competencies

Subject-specific Competencies
Concepts and Theories
- assessed

Method-specific Competencies
Analytical Competencies
- assessed

Decision-making
- assessed

Problem-solving
- assessed

Personal Competencies
Critical Thinking
- assessed

Self-direction and Self-management
- assessed

851-0703-00L Introduction to Law

Students who have attended or will attend the lecture "Introduction to Law for Civil Engineering and Architecture" (851-0703-03L) or "Introduction to Law" (851-0708-00L), cannot register for this course unit.

Particularly suitable for students of D-ARCH, D-MAVT, D-MATL

Abstract
This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Objective
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

Content
Basic concepts of law, sources of law.
Private law: Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.
Insights into the law of the EU and into criminal law.

Lecture notes
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Literature
Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

Examination block 2

Number Title Type ECTS Hours Lecturers
402-0043-00L Physics I O 4 credits 3V+1U S. P. Quanz

Abstract
Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.

Objective
The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.

Content
Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids)
Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).

Lecture notes
The lecture follows the book "Physics" by Paul A. Tipler.

Literature
Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company

103-0253-01L Parameter Estimation O 4 credits 3G E. Brockmann

Objective
- Beherrschung der Grundlagen der Parameterschätzung
- Erlangung von Kalkülssicherheit
- Erkennung von Problemen, die mit Parameterschätzungsverfahren gelöst werden können
- Im Stande sein, reale Problemstellungen auf die Parameterschätzungsmodelle abzubilden
- Befähigt sein, mit Messunsicherheiten umzugehen und Resultate in Bezug auf ihre Qualität / Unsicherheiten zu beurteilen
- Interdisziplinäre Anwendungsmöglichkeiten der Parameterschätzung erkennen

Content
- Unsicherheit / Messunsicherheit
- Verteilungen
- Varianzfortpflanzung
- Vermittelnde Ausgleichung
- Allgemeine Ausgleichung
- Zusatzbedingungen und a priori Information

Examination Block 3

Number Title Type ECTS Hours Lecturers
363-1004-00L Operations Research O 3 credits 2G S. Büttikofer van Oordt

Abstract
This course provides an introduction to operations research methods in the fields of management science and economics. Requisite mathematical concepts are introduced with a practical, problem-solving perspective.

Objective
- Introduction to building and using quantitative models in a business / industrial environment
- Introduction to basic optimization techniques (Linear Programming and extensions, network flows, integer programming, dynamic and stochastic optimization)
- Understanding the integration of quantitative models into the managerial decision process
The economic environment of today's companies is characterized by high cost pressure, declining margins, intensified international competition, rising customer requirements and increasingly strict regulations. Strategic and operational decisions at all management levels are becoming more and more complex due to the increasing amount of data, interrelationships, conditions and target criteria to be considered. Often it is no longer possible to solve operational tasks with experience and common sense alone and to adequately estimate the consequences of decisions without software support.

Quantitative models and methods of operations research and operations management offer decision support for complex problems. Mathematical optimization models are used to precisely formulate operational decision problems so that they can subsequently be analyzed and optimized using and applicable solution methods. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of operations research comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment and revenue management.

This course offers an introduction to operations research, emphasizing basic methodologies and underlying mathematical structures. The following topics are covered in detail:

- Introduction to System Modelling and Operations Research
- Linear models and the importance of linear programming
- Duality theory in linear programming and shadow prices
- Integer programming
- Dynamic optimization (under uncertainty) and applications in inventory management.

A printed script will be made available.

Prerequisites / notice

- Undergraduate calculus, linear algebra, probability and statistics are a prerequisite.
- Any standard textbook in Operations Research is a useful complement to the course.
- A printed script will be made available.

Lecture notes

- The lecture materials consist of a script, the slides and example calculations in Excel.
- The lecture materials will be distributed via Moodle two days before each lecture.

Appropriate literature in addition to the lecture materials will be handed out when required via Moodle.

Notice

This course has no prerequisites.
After completing this course, the participants should be equipped with the necessary tools to plan, analyze and evaluate geodetic networks. The lecture provides knowledge about the planning, computation and analysis of geodetic networks, as well as the use of data analysis methods in geodesy in general. The necessary mathematical and statistical methods are presented and applied using examples from geodesy. 

The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts. 

The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project. But also for company wide success.

### Elective Blocks

#### Geodesy and Satellite Navigation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0139-00L</td>
<td>Geodetic Data Analysis</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Schartner</td>
</tr>
<tr>
<td>103-0135-01L</td>
<td>Global Satellite Navigation Systems</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>G. Möller</td>
</tr>
</tbody>
</table>

**Abstract**

The lecture provides knowledge about the planning, computation and analysis of geodetic networks, as well as the use of data analysis methods in geodesy in general. The necessary mathematical and statistical methods are presented and applied using examples from geodesy.

**Objective**

After completing this course, the participants should be equipped with the necessary tools to plan, analyze and evaluate geodetic networks as well as to evaluate and analyze geodetic data in general. For typical geodetic tasks the participants should be able to provide concepts of solutions as well as to do the necessary programming work.

**Content**

Recapitulation of basics in statistics and probability theory (density and distribution functions, random variables, correlations, Monte Carlo simulation, hypothesis tests), linear and nonlinear least squares estimation, terrestrial and satellite-based observation equations, reference frames and transformations (global, local, astronomical), geodetic datum (free/constrained networks, full/partial trace minimization), quality control of geodetic methods (precision, reliability), robust estimation, time series analysis (decomposition, stochastic processes, parametric/nonparametric methods, regression models, spectral analysis and filtering, significance tests), basics of Kalman filtering (state space representation, Kalman equations, quality control).

**Literature**


Further literature will be provided during the course.

**Prerequisites / notice**

Linear algebra, basics in statistics and probability theory, parameter estimation

---

**Global Satellite Navigation Systems**


**Objective**

- Erlernen der theoretischen und praktischen Grundlagen der verschiedenen GNSS
- Verstehen der wichtigsten Fehlereinflüsse und der unterschiedlichen Beobachtungsverfahren

**Content**

- Überblick über die verschiedenen GNSS (GPS, GLONASS, Galileo, Beidou, QZSS und INRRISS)
- Systemkomponenten, Signalstrukturen, Referenz- und Zeitsystemen und Beobachtungsgleichungen für Pseudorange- und Phasenmessungen der GNSS
- Bildung von Differenzen und Linearkombinationen der ursprünglichen Beobachtungen
- Fehlereinflüsse: Satellitenbahnen und -uhren, troposphärische und ionosphärische Refraktion, Antennenphasenzentren, relativistische Einflüsse, Mehrwegeffekte und Messrauschen
- Einblick in die Bedeutung der speziellen und allgemeinen Relativitätstheorie für die GNSS
- Auswertestrategien und Beobachtungsverfahren sowie Methoden zur Lösung der Phasenmehrdeutigkeiten
- Referenzstationsnetze und Dienste
- Viele Anwendungsbeispiele
- Praktische und rechnerische Übungen für die Erfassung und Auswertung der GNSS-Messungen
Der Zugang zu den Unterrichtsmaterialien ist über folgenden Link möglich:
(Passwort wird in der 1. Vorlesung bekannt gegeben)

https://polybox.ethz.ch/index.php/s/jLRUTFfOmndM77T

Lecture notes

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed

Problem-solving not assessed

Social Competencies

Communication assessed

Cooperation and Teamwork not assessed

Personal Competencies

Creative Thinking assessed
Critical Thinking assessed

Digitisation and 3D Modelling

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0115-01L</td>
<td>Geodetic Measuring Technology and Laserscanning</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>A. Wieser, N. Meyer</td>
</tr>
</tbody>
</table>

Abstract

Advanced topics in geodetic metrology with focus on approaches to 3d modelling of local real world environments with higher accuracy.

Objective

By the end of this course, the students are able to create digital 3d models of the real world covering areas with an extension up to several 100 m with accuracies in the mm- to cm-level range. They can select the appropriate geodetic instruments or terrestrial laser scanners, plan and carry out the required working steps, test the equipment before use, and describe the quality of the results. They know a broad spectrum of visualization options and can assess their respective suitability for various application cases.

Content

- Overview: 3D Modelling from planning of data acquisition to visualization of the results
- Modern geodetic instruments
- Atmospheric effects
- Measurement techniques for high accuracy
- Introduction to terrestrial laser scanning
- Test and calibration of measurement instruments
- Point cloud processing: preprocessing, registration & georeferencing
- 3d modelling and visualization of objects, VR/AR/MR

Lecture notes

The slides and documents for enhanced study and further reading will be provided online.

Literature


Prerequisites / notice

The course is carried out in German. Basic knowledge of geodetic metrology is required as a prerequisite, corresponding to the learning objectives and content of the course Geodätische Messtechnik GZ. Besides lectures and data processing, the course also comprises extensive practical exercises in the field.

GIS and Cartography

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0717-00L</td>
<td>Geoinformation Technologies and Analysis</td>
<td>W</td>
<td>6 credits</td>
<td>5G</td>
<td>M. Raubal</td>
</tr>
</tbody>
</table>

Abstract

Geoinformationstechnologien und -analysen für Fortgeschrittene: Mobile GIS; Web-GIS & Geo-Web-Services; Spatial Big Data; Zeitliche Aspekte in GIS; Analyse von Bewegungsdaten; Benutzerschnittstellen Übungen: Web-GIS-Semesterprojekt in Gruppenarbeit - die Übungen finden auf Englisch statt!

Objective


Content

- Mobile GIS
- Web-GIS & Geo-Web-Services
- Spatial Big Data
- Zeitliche Aspekte in GIS
- Analyse von Bewegungsdaten
- Benutzerschnittstellen

Lecture notes

Vorlesungspräsentationen werden digital zur Verfügung gestellt.

Literature


Prerequisites / notice

GIS GZ

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Decision-making assessed

Media and Digital Technologies assessed
Problem-solving assessed

Social Competencies

Communication assessed

Cooperation and Teamwork assessed

Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed

Personal Competencies

Negotiation not assessed

Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed
### Spatial and Environmental Planning

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0325-02L</td>
<td>Integrated Spatial Planning in Cities and Districts</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>G. Di Carlo Alvarez, F. Günther, R. Streit</td>
</tr>
</tbody>
</table>

**Abstract**
Methodische und instrumentelle Grundlagen der Raumentwicklung werden aus integratierer Sicht (Städtebau, Freiraum, Verkehr) vermittelt und von den Studierenden konkret in einem Zürcher Stadtquartier als Semesterübung angewendet.

**Objective**
Die Studierenden lernen:
- Ein Repertoire an hilfreichen Werkzeugen sowie Denkmuster aus der Raumplanung kennen
- Quartiere eigenständig zu erkunden, Potentiale sowie Risiken der Raumentwicklung zu erkennen und zu dokumentieren
- Eigene Räumliche Entwicklungskonzepte zu entwerfen und zu präsentieren
- Massnahmen für Schlüsselgebiete zu konkretisieren, u.a. hinsichtlich Zeitplanung, Organisation und Kosten

**Content**
Die Vorlesung vermittelt methodische und instrumentelle Grundlagen zu planerischen Denkmustern und Repertoire sowie Hilfestellungen für Entwerfen, Argumentieren und Entscheiden.


Die Semesterübung erfolgt als Gruppenarbeit und wird der Note der Vorlesung angerechnet. Während der Vorlesungszeit sind mehrere Termine für die Gruppenarbeit, Werkstattgespräche und die Präsentation von (Zwischen-)Ergebnissen vorgesehen.

**Lecture notes**
Vorlesungsfolien und Unterlagen werden auf Moodle hochgeladen.

### Traffic Systems

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>101-0415-01L</td>
<td>Public Transport and Railways</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>A. Nash, H. Orth, S. Schranil</td>
</tr>
</tbody>
</table>

**Abstract**
Categorization of performance dimensions of public transport systems, and their implications to their design and operations.

**Objective**
Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.

**Content**
Fundamentals: Infrastructures and vehicle technologies of public transport systems; interaction between track and vehicles; passengers and goods as infrastructure users; management and financing of networks.

**Literature**
Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

**Lecture notes**
Slides, in English, are made available some days before each lecture.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
</tr>
</tbody>
</table>

**Techniques and Technologies**

**Decision-making**

**Media and Digital Technologies**

**Problem-solving**

**Project Management**

**Leadership and Responsibility**

**Self-presentation and Social Influence**

**Sensitivity to Diversity**

**Negotiation**

**Adaptability and Flexibility**

**Creative Thinking**

**Critical Thinking**

**Integrity and Work Ethics**

**Self-awareness and Self-reflection**

**Self-direction and Self-management**

### Network Infrastructure

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>052-0609-00L</td>
<td>Energy and Climate Design I</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>A. Schlüter</td>
</tr>
</tbody>
</table>

**Abstract**
This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

**Objective**
At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=11917). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

**Literature**
Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

**Fostered competencies**

<table>
<thead>
<tr>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
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<tr>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Integrity and Work Ethics</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
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</table>

**Techniques and Technologies**

**Decision-making**

**Media and Digital Technologies**

**Problem-solving**

**Project Management**

**Leadership and Responsibility**

**Self-presentation and Social Influence**

**Sensitivity to Diversity**

**Negotiation**

**Adaptability and Flexibility**

**Creative Thinking**

**Critical Thinking**

**Integrity and Work Ethics**

**Self-awareness and Self-reflection**

**Self-direction and Self-management**

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**Autumn Semester 2022**

Data: 01.11.2022 12:41

Page 1955 of 2416
Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:

1. Local potentials
2. Demand
3. Supply

The slides of the lecture serve as lecture notes and are available as download.

A list of relevant literature is available at the chair.

This course can only be taken if Energy and Climate Design II is taken in the following semester, as the group work is connected and extends throughout the year.

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed

Social Competencies
- Communication: assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-direction and Self-management: assessed

Adaptability and Flexibility: not assessed
Creative Thinking: not assessed
Critical Thinking: assessed
Integrity and Work Ethics: not assessed
Self-awareness and Self-reflection: not assessed
Self-direction and Self-management: not assessed

Abstract
The means and potentials in the field of urban planning and design are pointed out from different perspectives in order to shape the city in the sense of a future-proof and humane environment. To this end, the basic principles are explained and concrete methods of urban design are presented.

Objective
The goal is to provide students with a broad systemic basic knowledge, that enables them to synthesize and evaluate complex urban design and planning problems.

Content
The lecture series imparts basic knowledge in urban planning and design. Pressing questions and main topics of contemporary urban design practice and theory will be addressed. The focus is on illustrating the richness of relationships as well as the potential of the discipline and its handling in everyday urban planning and design practice.

Lecture notes
There is no script to the lecture series. The lectures are recorded on video and made available online on [http://www.video.ethz.ch/lectures.html](http://www.video.ethz.ch/lectures.html) a few days after each lecture.

Literature
At the end of the year course a reader with secondary literature will be made available for download.

Further Informations:
[https://www.staedtebau.arch.ethz.ch](https://www.staedtebau.arch.ethz.ch)

Course Catalogue of ETH Zurich

Recommended Electives of Bachelor Degree Programme

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0241-00L</td>
<td>Cartography Lab 1</td>
<td>W</td>
<td>6 credits</td>
<td>13S</td>
<td>L. Hurni</td>
</tr>
<tr>
<td>Abstract</td>
<td>Independent practical work in cartography.</td>
<td></td>
<td></td>
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<tr>
<td>Objective</td>
<td>Independent practical work in cartography.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Choice of theme upon individual agreement.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Cartography Fundamentals</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Information sheet will be distributed by the supervisors.</td>
<td></td>
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<td></td>
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</tr>
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</table>

| 103-0242-00L | Cartography Lab 2 | W    | 8 credits | 17S  | L. Hurni  |
| Abstract  | Independent practical work in cartography. |
| Objective | Independent practical work in cartography. |
| Content   | Choice of theme upon individual agreement. |
| Lecture notes | Information sheet will be distributed by the supervisors. |
| Prerequisites / notice | Cartography Lab 1 |

Science in Perspective

see [Science in Perspective: Type A: Enhancement of Reflection Capability](#)
### Bachelor’s Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0006-10L</td>
<td>Bachelor’s Thesis</td>
<td>O</td>
<td>10 credits</td>
<td>21D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

**Abstract**

The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work.

**Objective**

Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

**Content**

The contents base upon the fundamentals of the Bachelor Programme. Students can choose from different subjects and tasks. The thesis consists of both a written report and an oral presentation.

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### Geospatial Engineering Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
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</table>

### ECTS

**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>History, impact and principles of the design and operation of transport systems</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
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</tr>
<tr>
<td></td>
<td>Introduction of the basic principles of the design and operation of transport systems (road, rail, air) and of the essential pathways of their impacts (investment, generalised costs, accessibilities, external effects), referring to relatively constant, and factors with substantial future uncertainty, in the past and expected evolution of transport systems.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transport systems and land use; network design; fundamental model of mobility behaviour; costs and benefits of mobility; transport history</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Classification of public transport systems; Characteristics of rail systems, bus systems, cable cars and funiculars, unconventional systems; introduction to logistics; fundamentals of rail freight transports; freight transport systems; intermodal transportation</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Network layout and its impact on road traffic. Traffic control systems for urban and inter-urban areas. Fundamentals of road safety and infrastructure maintenance.</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>103-0317-00L</td>
<td>Spatial Planning and Development</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>D. Kaufmann, A. Kuitenbrouwer</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The course deals with important theoretical, material and methodical foundations for action and decision-making of spatial relevance. This course discusses central tasks and possible solutions for current and future challenges of spatial development in Switzerland and Europe.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td><strong>Objective</strong></td>
<td></td>
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<td>Spatial development deals with the development, formation and arrangement of our environment. In order to be able to mediate between the different demands, interests and projects of multiple actors, a forward-looking, action-oriented and robust planning is necessary. It is committed - in the sense of a sustainable spatial development - to the economical handling of resources, in particular of the non-replicable resource soil.</td>
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<td>The lecture introduces necessary basic knowledge and is based on the following main topics:</td>
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<td>- Planning approaches and The (political) steering of spatial development</td>
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<td>- Interplay of formal and informal processes and processes across different scales of spatial development</td>
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<td>- Methods of action-oriented planning in situations of insecurity</td>
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<td>- Integrated space and infrastructure development</td>
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<td>- Different types of participation in spatial development</td>
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<td>By taking up the lecture, the students are able to recognize cross-scale, complex tasks of spatial development and transformation and to use their theoretical, methodical and professional knowledge to clarify them.</td>
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**Abstract**

In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.
Objective

The aims of this course are:
1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.

Content

In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes

No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites / notice

The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

Fostered competencies

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103-0377-10L Basics of RE&IS

Only for Spatial Development and Infrastructure Systems

MSC.

Abstract

The course Basics of RE&IS provides essential knowledge for the Master's degree program in Spatial Development & Infrastructure Systems. It teaches the basics of technical-scientific work, such as scientific writing, literature review, and effective presentation and communication of results.

Objective

-Students will be able to identify, name, and define the content taught and understand the necessity, significance, and application of the standards in scientific work.
-Students will be able to apply the content, implement it in different examples and use it to solve the exercises and the semester assignment.
-Students develop a common understanding with regard to their methodological knowledge and can henceforth work scientifically at an appropriate level.
-Students will be able to analyze and differentiate scientific sources and apply them in their work in a structured way.
-Students systematically compare and present their results in an argumentative manner.
-Students develop, formulate, and design a scientific report.
-Students produce results in collaboration with their group.
-Students present results in an engaging presentation with their group using attractive and formally correct visualizations, maps, or diagrams.
-Students discuss and give critical feedback in the form of peer-assessments of other students.

J. Van Wezemael, K. W. Axhausen, F. Corman, C. Sailer

Autumn Semester 2022
Students will learn the basics of scientific work and practice their skills within the framework of three separate exercises (formative) as well as an ungraded semester performance, which consists of two parts and will be worked out in groups of two to three students.

In the first half of the semester, students will learn the theoretical basics and apply and understand these in the context of the exercises. In the second half of the semester, the students will work on a written scientific report applying the methods learnt in the first half of the semester. The results of the report should be communicated in an effective and clear oral presentation taped on video. The final videos, as well as the exercises in the first part of the course will be discussed and evaluated among the students in class (peer-assessment).

- Exercise 1: Literature search & referencing
- Exercise 2: Scientific writing – report structure, paragraph structure, language style
- Exercise 3: Maps, Graphs & Visualizations
- Ungraded semester performance: consists of (1) written report on topic of interest and (2) oral presentation on video

Students will be supervised by the course instructors throughout the course. Furthermore, feedback and discussion opportunities will be given by other students by the principle of peer assessment.

The main course lead changes periodically between the following RE&S chairs: Infrastructure Management (IM), Transportation Systems (TS), Traffic Engineering (SVT), Transport Planning (VPL), Spatial Development and Urban Policy (SPUR), Planning of Landscape and Urban Systems (PLUS) and Spatial Transformation Laboratories (STL).

Lecture notes

All documents relevant for the course (slides, literature, further links, etc.) are provided centrally via the Moodle platform.

Literature

Axthausen, K.W. (2016) Style Guide for Student Dissertations, IVT, ETH Zürich, Zürich (available as download under learning materials)
ETH (2017) Citation etiquette: How to handle the intellectual property of others, ETH, ETH Zürich, Zürich (last retrieved 29.11.2017)

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Abstract

Spatial planners ensure our built environment optimally meets our future needs. This course explains how spatial planners can evaluate proposed modifications to network infrastructure when there is substantial future uncertainty with respect to requirements, and how to develop implementation plans taking into consideration asset life cycles.

Objective

Spatial planners ensure our built environment optimally meets our future needs. This is challenging, as the built environment is a large and complex system, which interacts extensively with the natural environment. Additionally, there is considerable uncertainty with respect to the expectations of the built environment in the future, due to the uncertain environment in which we live, e.g. changing technologies and the changing climate. It is in the face of this complexity and uncertainty that spatial planners need to propose potential improvements and defend them convincingly to a large and diverse set of stakeholders.

The objective of this course is to provide spatial planners with an introduction to two essential tools in this regard. The first tool is a methodology to systematically take into consideration the future uncertainty in infrastructure requirements when proposing changes to the built environment. This involves the identification of key uncertainties, modelling their effect on infrastructure requirements and assessing how changes in future needs and the environment may affect future decisions. The second tool is a methodology to systematically estimate the life cycles of infrastructure assets. This methodology can be used together with the state of the existing infrastructure assets to develop optimal implementation plans.

More specifically, upon completion of the course students will understand how:
- to identify and quantify the service being provided by the built environment
- to construct an objective function to be used in the evaluation of proposed modifications to estimate changing societal needs and their potential effect on required infrastructure
- to develop concepts for flexible/robust infrastructure alongside traditional infrastructure
- to simulate future scenarios to evaluate the costs and effects on the service provided over time by infrastructure
- to estimate the service provided by existing infrastructure now and in the future
- to determine optimal maintenance strategies for infrastructure
- to convert them into optimal intervention programs, which can be used to build strong arguments as to when system modifications should be implemented.
The course consists of 9 lectures, 2 projects and 5 help sections. The two hour weekly lecture period is used as follows:

1. Planning infrastructure interventions – This lecture provides an introduction to the course and why it is useful in helping spatial planners propose and evaluate modifications to the built environment. The requirements for successful completion of the course are discussed and the two projects are introduced.

2. Service – Arguments for modifying the built environment are built on meeting the future needs of stakeholders. This week we present how to identify, quantify and value the service provided by the built environment. The measures of service, along with intervention costs are used to construct an objective function to be used in the evaluation of proposed modifications.

3. Changing needs – Trying to modify the built environment to meet future needs, requires estimating them. This week we discuss how to estimate them and their potential effect on required infrastructure.

4. Robust and flexible infrastructure – In the face of large amounts of future uncertainty it is useful to have either robust infrastructure, i.e. infrastructure that meets a large range of possible future needs, or flexible infrastructure, i.e. infrastructure that can be easily modified to meet different possible future needs. This week we discuss the concepts of robustness and flexibility and demonstrate their roles in maximizing the net-benefit of infrastructure.

5. Evaluating robust and flexible infrastructure – Robust and flexible infrastructure sometimes comes with increased costs. Whether or not the costs are worth it depends on a myriad of factors. This week we present a methodology that helps you develop robust and flexible infrastructure and evaluate their costs and benefits over time.

6. Simulating the uncertain future – As a key aspect to evaluating robust and flexible infrastructure is simulating what might happen in the future, this week, we explain how use Monte Carlo simulations and conduct an in class exercise so that you have an enhanced understanding of how it is done.

7. Help sessions 7-9 – We use the lecture periods to answer any questions you might have on project 1.

8. Existing infrastructure – Deciding how to modify infrastructure does not only require thinking about how to meet future needs. It also requires thinking about how the existing infrastructure is likely to provide service in the future. This week, we discuss the connection between provided service and the state of the infrastructure and use a common methodology to predict their evolution over time.

9. Maintenance strategies – It is useful to know the optimal maintenance intervention strategies for infrastructure assets when considering how to modify infrastructure to accommodate future needs, as it is easier to justify expenditures when a maintenance intervention is planned than immediately afterwards, when it is in a like new state. This week we explain how optimal intervention strategies are estimated.

10. Maintenance programs – As planning periods approach, exact decisions need to be made as to which interventions will be executed, taking into consideration network level constraints, such as budgets. This week we demonstrate how the state of assets together with the optimal maintenance strategies and network level constraints can be combined to determine optimal maintenance programs. These programs are used to optimally integrate both maintenance and modification interventions into one intervention program.

11. Help sessions 13 and 14 – We use the lecture periods to answer any questions you might have on project 2.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R. The course uses a combination of qualitative and quantitative approaches. The course has no prerequisites.

Lecture notes

- The lecture materials consist of handouts, the slides, and example calculations in Excel.
- The lecture materials will be distributed via Moodle two days before each lecture.

Literature

Appropriate literature will be handed out when required via Moodle.

Prerequisites / notice

This course has no prerequisites.

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Abstract

Introduction to the Programming Language R

R is one of the most popular programming language in science and practice for data analysis, modelling and visualisation. In this course, you will learn the basics of R and some common applications of R, such as making plots, regression analysis and working with spatial data. The weekly computer labs start with a short lecture followed by exercises that have to be handed in to pass the course.

Objective

The overall objective of this course is to provide an introduction to the programming language R and to build confidence to apply R in other courses. More specifically, the objectives are:

- Understand how to import and export data, and how to work with the most important types of R-objects (e.g. vectors, data frames, matrices and lists).
- Learn how to create meaningful and visually attractive graphics and apply this knowledge to several datasets.
- Learn how to apply several types of important functions (e.g. for- and while-loops, if-else statements, data manipulation).
- Understand descriptive statistics and regression analysis and apply this knowledge to analyse several datasets.
- Understand the possibilities of analysing and plotting spatial data.
- Learn how to write own functions.

Content

The course has a strong focus on “learning by doing”. During the weekly computer lab sessions, students will be given an introduction to the programming language R. Each lab session will start with a short introductory lecture, after which students work through the script and complete the exercises. During the lab sessions, the lecturers will be available to answer individual questions. The main topics that will be covered in the lab sessions are:

- importing and exporting data
- types of R-objects
- data scraping
- plotting data
- descriptive statistics
- data manipulation
- conditionals and loops
- regression analysis
- plotting and analysing spatial data
- writing own functions

In the 7th and 14th week of the course, students have the time to finish the exercises that should be handed in at the end of those weeks.

Lecture notes

A script with theory, examples and exercises will be handed out at the beginning of the course. Data for the exercises will be made available via Moodle.

Literature


Prerequisites / notice

No prior knowledge of R or any other programming language is required for this course.
The focus of the lecture Site & Project Development is on larger contiguous areas or sites and their urban, open space and infrastructural development. In this course, students work in a semester exercise in which they "develop" a specific large-scale project from practice and evaluate it economically, strategically and in terms of feasibility.

Objective

- Investigate and understand a given concrete project area and identify, evaluate and articulate the current problems and relevant issues within this area.
- Consolidate their knowledge in the essential topics of site & project development and apply this in a well-founded, argued and creative manner to address the task at hand.
- Organize and structure themselves while acquiring responsibilities in their interdisciplinary project teams. The teams consist of three to five fellow students that must develop innovative, viable and resilient concepts for a real project development in a given area. Their considerations should be presented in written form (project report) and in linguistic-visual form (final presentation). At the end of the course, the students critically reflect on their experiences with the group work process together with the course instructors.
- Acquire methodological knowledge in location & market analysis, 3D visualization of a project as well as in the financial assessment of a large-scale real estate project and use this knowledge to justify their considerations and evaluate their proposal.
- Development and strengthening of their individual position as planners (spatial, urban, transport planners, etc.) in relation to the questions formulated in the proposed project within the field of Site & Development as well as within their own discipline.

Content

The lecture is divided into several thematic sections analogous to the essential topics of Site & Project Development. The students are accompanied both in the semester exercise and in the individual lectures by a large number of external guest speakers from the practical field, which means that the lecture will not only thematically examine the relevant areas of Site & Project Development, but also will offer the students exclusive, practice-oriented insights. The relevant methodological knowledge for the semester exercise is imparted and, due to the proximity to practice, the students gain exclusive insights into possible professional fields of activity. In this lecture, students apply their already acquired and newly learned skills, especially in interdisciplinary teams, and work on an exciting, motivating and relevant question from the practice.

Major topics covered in the lecture include:
- Urban planning
- Location and market analysis
- Real estate development, financing and valuation
- Project development and decision-making from the perspective of investors
- Open space design and landscape architecture
- Sustainable building and sustainability certification
- Mobility, parking issues, travel models
- Cooperative planning and participation processes, mediation
- Gendered planning in project development
- Inner development & urban quality

Parallel to the lecture series, students work in interdisciplinary teams on a real-life task. In the course of the semester exercise, the lecture material is deepened and what has been learned is applied. The students visit the project area at the beginning of the semester as part of an excursion. Specific large-scale projects such as the Gaswerkareal Bern, the Sihl-Manegg Areal Zurich (GreenCity) or the Areal Alter Pilatusmarkt (Nidfeld) Lucerne will be dealt with. For the possible development of the given site, visions are developed by the students on the basis of a comprehensive location and market analysis and a utilization concept is developed. In the process, the students are accompanied by experts and regularly discuss their ideas and proposed solutions with their supervisors.

Lecture notes

- Handouts of the lectures
- Extracts from relevant scientific articles and theory literature
- Exercise material

Literature

Download: https://irl.ethz.ch/de/education/vorlesungen/msc/project_development.html

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103-0417-02L Methodology of Planning Research and Practice

*W* 3 credits 2G
A. Peric Momcilovic, T. Hug, R. Streit

**Abstract**
This course deals with scientific and applied methods and the ways of thinking that are useful in planning practice as well as in scientific research. Students are offered interdisciplinary knowledge from planning practice and research, behavioural economics and social sciences. New perspectives on planning are opened up, which can lead to better results in future projects and research.

**Objective**
Keeping the general aim of exploring the basic methodologies in spatial planning research and practice, the specific course learning objectives are as follows:
- to address complex real-world spatial problems in adequate ways
- to know relevant theories and maxims that are subject to specific methods of problem solving
- to identify key questions and key concepts in contemporary planning research
- to select appropriate research methods to properly address the research questions

In practical terms, students:
- learn to deal with uncertainties and estimate quantities
- improve their ability to take decisions based on incomplete data and information
- are informed about different (qualitative and quantitative) methods and techniques for spatial research
- learn about different types of research (theoretical, empirical, action-oriented, qualitative, quantitative)
- get skilled for writing simple research essays
- are urged to question their own knowledge and challenge the course of action taken in planning processes

Does not take place this semester. Only for master students, otherwise a special permission by the lecturer is required.
Content

The course is based on the following questions:

How do we deal with complex issues in planning?
- Forms of knowledge, half-knowledge and not knowing
- Occurrence and explanation patterns for irrational behaviour
- Spatial research and planning practice
- Planning maxims
- Mapping complex topics in research questions

How do we generate knowledge about complex issues?
- Methods for scientific data generation
- Applied handling of quantities and probabilities
- Estimating despite uncertainties
- Opportunities of digitisation in planning (Participation, BigData)

How do we react to complex questions in planning?
- Methods of scientific data analysis
- Making decisions despite incomplete information
- Dealing with robustness and fragility

More specifically, the lectures focus on the following topics (NB: Some content units will be presented in English, they are marked with asterisk below)
- (Half-) knowledge/behaviour/irrationalities
- Initial situation: Solving complex problems
- Forms of knowledge, knowing of not knowing something, not knowing of not knowing something
- Behavioural patterns, occurrence and explanation patterns for irrational behaviour
- Methods for solving complex tasks in planning practice
- Spatial research and planning practice - connections, differences, overlaps
- Challenges in the solution of complex tasks: System delimitation, interdisciplinarity, retrospective vs. prospective approach (descriptive vs. action-oriented, *reflected scenario building*)
- Planning maxims
- *Methodology in spatial research
- *Research design
- *Research questions (types of research questions; research questions, hypotheses and theories); justification of research question
- Data generation methods (interviews and questionnaires, ethnography and observation, documents, official statistics)
- Dealing with quantities, estimations, anchor effect
- Importance of scales and key figures in planning
- Estimation methods
- Danger of the anchor effect
- Digitization in planning
- New data sources and sizes
- Opportunities and challenges through digitisation in planning
- Data analysis methods (quantitative and qualitative data; quantitative analysis of survey data; qualitative analysis - content analysis, discourse analysis, case study, comparative research)
- *Research ethics
- Decisions based on incomplete information
- Dealing with complex systems/roughness
- *Role of science in planning - the perspective of both research and practice

Lecture notes

Learning materials: available online (Moodle) before corresponding lecture.

Literature


Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

851-0707-00L Space Planning Law and Environment

Particularly suitable for students of D-ARCH, D-BAUG, D-USYS

W 2 credits 2G O. Bucher

Abstract

System of swiss planning law,
Constitutional and statutory provisions,
Space planning and fundamental rights,
Instruments,
Application, legal protection, enforcement,
Practical training.
Objective
Basic understanding of nature and function of space planning from a legal point of view. Basic knowledge of space planning instruments, relationship between space planning and constitutional law (especially property rights), solving of practical cases.

Content

Lecture notes
Haller, Walter/Karlen, Peter, Raumplanung-, Bau- und Umweltrecht, 3.A., Zürich 1999

103-0327-00L
History of Spatial Planning
W 3 credits

Objective
The course examines the patterns of cleavage, conflict, convergence of interest, and consensus that have influenced spatial planning.

Content
Social, cultural, and economic forces will be analyzed for the roles they have played in shaping the landscapes and cityscapes and the answers spatial planning had to spatial development. The course focuses on the history of planning ideas, paradigms and approaches. A link is made to current challenges in spatial planning. Students will critically discuss the challenges spatial planning is facing today.

Lecture notes
Handouts will be available.

Literature


Daniel Kurz: Die Disziplinierung der Stadt - Moderner Städtebau in Zürich 1900 bis 1940. gta Verlag 2008


103-0569-00L
European Aspects of Spatial Development
W 3 credits

Objective
Following the insight into historical perspective and contemporary models of governance and planning, the course focuses on the international dimension of spatial planning in Europe. This includes a discussion of how European spatial policy is made and by whom, how planners can participate in such process and how they can address transnational challenges of spatial development cooperatively.

Content
- European spatial policy agenda: introduction and basic directives
- governance models
- planning models; collaborative planning model (main concepts & critics)
- post-positivist approach to spatial planning
- transnational spatial planning in Europe; questioning the European spatial planning; spatial development trends in Europe
- EU as a political system: EU institutions & non-EU actors
- planning families in Europe; the European spatial planning agenda
- spatial planning strategies and programs on territorial cooperation
- the notion of planning culture and planning system; planning cultures in Europe
- basic characteristics of planning systems in Europe
- the relevance of European transnational cooperation for spatial planning
- European transnational initiatives

Lecture notes
The documents for the lecture will be provided at the moodle.
Literature

Obligatory literature:

Recommended literature:
Governance models:

Planning models:

EU as a political context:

Territorial cooperation in Europe:

Planning families and cultures:

Planning systems in Europe:

Prerequisites / notice

Only for master students, otherwise a special permission by the lecturer is required.

Fostered competencies

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Abstract

The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective

- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies

Content

- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes

A script and presentation slides for each exercise will be provided on Moodle.

Literature

Will be named in the lecture.

Prerequisites / notice

Basic GIS skills are strongly recommended.

103-0347-01L Landscape Planning and Environmental Systems (GIS W 3 credits 2U A. Grêt-Regamey, C. Brouillet, M. Galleguillos Torres, N. Klein

Autumn Semester 2022
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: not assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: assessed
- Problem-solving: assessed
- Project Management: assessed

Social Competencies
- Communication: assessed
- Cooperation and Teamwork: assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

701-1631-00L Foundations of Ecosystem Management

Number of participants is limited to 35.
Priority is given to the target groups until 26.09.2022.

Target groups
- MAS ETH in Raumplanung
- MAS ETH in Sustainable Water Resources
- Science, Technology and Policy MSc
- Environmental Sciences MSc
- Agricultural Sciences MSc

Waiting list will be deleted on 30.09.2022

Abstract
This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

Objective
Students should be able to
a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales;
b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

Content
Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

Lecture notes
No Script

Literature

701-1453-00L Ecological Assessment and Evaluation

Abstract
The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

Objective
Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Lecture notes
Powerpoint slides are available on the webpage. Additional documents are handed out as copies.

Literature
Basic literature and references are listed on the webpage.
A reading list will be provided for the exams.

The course covers the basic history and theory of garden design and landscape architecture from its beginnings to the 21st century. The course aims to raise awareness of a changing perception of nature and landscape.

The lecture series on History and Theory of Garden Design and Landscape Architecture deals with the historical development of designed nature, from the beginnings of cultural landscapes and gardens to 21st century landscape architecture. In the analysis of each era, the focus is on the spatial and cultural relationship between the garden, the city and the landscape, as well as the changing perceptions of nature and its representation.

Exchange students or students from other departments: Students, who are attending only one semester, may pass the oral end-of-semester examination. Test-relevant literature will also be made available for download for this purpose. The students are requested to get in touch by email with the Chair.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

### Prerequisites / notice

The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Landscape Architecture I

**Abstract**
Introduction to the history and theory of garden design and landscape architecture. Analysis of the design of historical gardens and landscapes within the cultural background.

**Objective**
The course covers the basic history and theory of garden design and landscape architecture from its beginnings to the 21st century. The course aims to raise awareness of a changing perception of nature and landscape.

**Content**
The lecture series on History and Theory of Garden Design and Landscape Architecture deals with the historical development of designed nature, from the beginnings of cultural landscapes and gardens to 21st century landscape architecture. In the analysis of each era, the focus is on the spatial and cultural relationship between the garden, the city and the landscape, as well as the changing perceptions of nature and its representation.

**Lecture notes Literature**
Handouts and a reading list will be provided.

A reading list will be provided for the exams.

**Prerequisites / notice**
Bachelor students: The content of the lectures as well as texts and exam-relevant literature provided by the Chair make up the basis for preparing for the exam. The lecture series is conceived as a yearlong course. Since the written session examination will test knowledge from both semesters, it is necessary to fully attend the lectures of both courses "Landscape Architecture I" and "Landscape Architecture II". The themes of the examination will be announced at the end of the semester. The Chair will provide literature and texts available for download as pdfs. These allow a more in-depth understanding of the lecture material.

Exchange students or students from other departments: Students, who are attending only one semester, may pass the oral end-of-semester examination. Test-relevant literature will also be made available for download for this purpose. The students are requested to get in touch by email with the Chair.

Participatory Environmental Modeling

**Abstract**
The lecture accompanies students into a participatory modelling process. We explore environmental topics such as urban agriculture or nature and its representation.

**Objective**
In this course students will learn:

- The process of developing a model to address an environmental problem: from choosing an appropriate technique (Agent-based modelling, Bayesian Networks and System dynamics), to conceptualization and model building.
- Communication and facilitation skills to foster effective and legitimate collaboration with stakeholders.

Students then apply this knowledge and skills to a real-life case study, creating a model with stakeholders to address an environmental problem.

**Fostered competencies**

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**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Prerequisites / notice**

Advanced Environmental Assessments

**Abstract**
Master students in Environmental Engineering choosing module Ecological Systems Design are not allowed to enrol 102-0317-00 Advanced Environmental Assessments (3KP) as already included in 102-0307-01 Advanced Environmental, Social and Economic Assessments (5KP).

**Objective**
This course deepens students' knowledge of the environmental assessment methodologies and their various applications. This course has the aim of deepening students' knowledge of the environmental assessment methodologies and their various applications. In particular, students completing the course should have the

- Ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- Knowledge about the current state of the scientific discussion and new research developments
- Ability to properly plan, conduct and interpret environmental assessment studies
- Knowledge of how to use LCA as a decision support tool for companies, public authorities, and consumers
Content
- Inventory developments, transparency, data quality, data completeness, and data exchange formats
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Recent development in impact assessment
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Uncertainty analysis
- Subjectivity in environmental assessments
- Multicriteria analysis
- Case Studies

Lecture notes
No script. Lecture slides and literature will be made available on Moodle.

Literature
Literature will be made available on Moodle.

Prerequisites / notice
Basic knowledge of environmental assessment tools is a prerequisite for this class. Students that have not done classwork in this topic before are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. 2016: Environmental Life Cycle Assessment, CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Fostered competencies

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Method-specific Competencies

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Personal Competencies

| Critical Thinking                               | assessed                |                                |                 |
|------------------------------------------------|                        |                                |                 |


Abstract
The Chair of Sociology presents a review of two decades of social and urban research at the Department of Architecture, ETH Zurich. This lecture series will host researchers who will present the methods, experiences, and findings from some of the important urban research projects undertaken at the Department over the last two decades.

Objective
The lecture series, Methods of Urban Research presents the methodology of sociological analysis developed over the years by the Chair of Sociology, which can be used in architectural and urban design. It provides practical experience with the results of the SNSF study on the analysis of urban qualities and discusses the topicality of the ETH Studio Basel's urban portrait of Switzerland. Further, it provides an insight into international research on urbanization processes in large metropolises and in territories characterized by extensive urbanization. The synopsis provides a kaleidoscopic overview of the diverse methods used in urban research today.

In order to receive a grade for the seminar, the participants are expected to work in groups of two and are required to submit a five-page (2000 words) report summarizing a method(s) they found relevant in the lecture series. Please make a description and a critical analysis of this method and make a proposal how to apply it to a topic and a site of your choice.

Content
22.09. Die Anfänge: Öffentliche Räume und Zürich West
Christina Schumacher, Bernadette Fülscher, Verena Poloni und Cordula Püstow
29.09. 21 Years of Urban Sociology at the Department of Architecture
Christian Schmid
06.10. The Young Housing Cooperatives in Zürich and the INURA Coop Initiative
Ileana Apostol and Philipp Klaus
13.10. Soziologie im Entwurf: Methoden und Erkenntnisse
Caroline Ting
20.10. Ethnography and Urban Research
Alice Hertzog and Lindsay Howe
03.11. ETH Studio Basel und das städtebauliche Portrait der Schweiz
Emanuel Christ, Mathias Gunz, Christian Müller Inderbitzin and Milica Topalović
10.11. Vergleichende Stadtforschung und experimentelle Methoden
Monika Streule
17.11. Urbane Qualitäten: Ein Forschungsprojekt
Lukas Küng, Simon Kretz und Thomas Klasling
24.11. Zürich erforschen
Gabriela Muri Koller
01.12. Journeys through Extended Urbanisation
Nitin Bathla
08.12 Final Discussion

Major in Transport Systems and Behaviour

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<tr>
<th>Number</th>
<th>Title</th>
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<tr>
<td>101-0427-01L</td>
<td>Public Transport Design and Operations</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>F. Corman, T.-H. Yan</td>
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Abstract
This course aims at analyzing, designing, improving public transport systems, as part of the overall transport system.
Objective

Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view

At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.

Content

Basics for line transport systems and networks
Passenger/Supply requirements for line operations
Objectives of system and network planning, from different perspectives and users, design dilemmas
Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport

Planning process, from demand evaluation to line planning to timetables to operations
Matching demand and modes
Line planning techniques
Timetabling principles
Allocation of resources
Management of operations
Measures of realized operations
Improvements of existing services

General introduction:
Lecture notes

Content

Lecture slides are provided.

Literature

Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed
Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed
Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics not assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

151-0227-00L Basics of Air Transport (Aviation I) W 4 credits 3G P. Wild

Abstract

In general the course explains the main principles of air transport and elaborates on simple interdisciplinary topics. Working on broad 14 different topics like aerodynamics, manufacturers, airport operations, business aviation, business models etc. the students get a good overview in air transportation. The program is taught in English and we provide 11 different experts/lecturers.

Objective

The goal is to understand and explain basics, principles and contexts of the broader air transport industry. Further, we provide the tools for starting a career in the air transport industry. The knowledge may also be used for other modes of transport. Ideal foundation for Aviation II - Management of Air Transport.
Content
Weekly: 1h independent preparation; 2h lectures and 1 h training with an expert in the respective field

Concept: This course will be taught as Aviation I. A subsequent course - Aviation II - covers the "Management of Air Transport".

Content: Transport as part of the overall transportation scheme; Aerodynamics; Aircraft (A/C) Designs & Structures; A/C Operations; Aviation Law; Maintenance & Manufacturers; Airport Operations & Planning; Aviation Security; ATC & Airspace; Air Freight; General Aviation; Business Jet Operations; Business models within Airline Industry; Military Aviation.

Technical visit: This course includes a guided tour at Zurich Airport and Dubendorf Airfield (baggage sorting system, apron, Tower & Radar Simulator at Skyguide Dubendorf).

Lecture notes
Preparation materials & slides are provided prior to each class

Literature
Literature will be provided by the lecturers, respectively there will be additional Information upon registration (normally available in Moodle)

Prerequisites / notice
The lecture is planned as class teaching.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking

101-0417-00L Transport Planning Methods
W 6 credits 4G K. W. Axhausen

Abstract
The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis.

Objective
- Knowledge and understanding of statistical methods and algorithms commonly used in transport planning
- Comprehend the reasoning and capabilities of transport models
- Ability to independently develop a transport model able to solve / answer planning problem
- Getting familiar with cost-benefit analysis as a decision-making supporting tool

Content
The course provides the necessary knowledge to develop models supporting the solution of given planning problems and also introduces cost-benefit analysis as a decision-making tool. Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/ policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Lecture notes
Moodle platform (enrollment needed)

Literature

101-0437-00L Traffic Engineering
W 6 credits 4G S. Mousavi, M. Makridis

Abstract
Fundamentals of traffic flow theory and control.

Objective
The objective of this course is to fully understand the fundamentals of traffic flow theory in order to effectively manage traffic operations. By the end of this course students should be able to apply basic techniques to model different aspects of urban and inter-urban traffic performance, including congestion.

Content
Introduction to fundamentals of traffic flow theory and control. Includes understanding of traffic data collection and processing techniques, as well as data analysis, traffic modeling, and methodologies for traffic control.

Lecture notes
The lecture notes and additional handouts will be provided during the lectures.

Literature
Additional literature recommendations will be provided during the lectures.

Prerequisites / notice
Verkehr III - Road Transport Systems 6th Sem. BSc (101-0415-00L)
Special permission from the instructor can be requested if the student has not taken Verkehr III
Abstract

Basic characteristics of railway vehicles and their interfaces with the railway infrastructure:
- Transportation tasks and vehicle types
- Running dynamics
- Mechanical part of rail vehicles
- Brakes
- Traction chain and auxiliary supply
- Railway power supply
- Signalling systems
- Standards
- Availability and safety
- Traffic control and maintenance

Objective

- Overview of the technical characteristics of railway systems
- Know-how about the design and construction principles of rail vehicles
- Interrelationship between different fields of engineering sciences (mechanics, electro and information technology, transport systems)
- Understanding tasks and opportunities of engineers working in an environment which has strong economical and political boundaries
- Insight into the activities of the railway vehicle industry and railway operators in Switzerland
- Motivation of young engineers to start a career in the railway industry or with railway operators

Content

Est I (Herbstsemester) - Begriffe, Grundlagen, Merkmale

1 Einführung:
1.1 Geschichte und Struktur des Bahnsystems
1.2 Fahrdynamik

2 Vollbahnfahrzeuge:
2.3 Mechanik: Kasten, Drehgestelle, Lauftechnik, Adhäsion
2.2 Bremsen
2.3 Traktionsantriebssysteme
2.4 Hilfsbetriebe und Komfortanlagen
2.5 Steuerung und Regelung

3 Infrastruktur:
3.1 Fahrweg
3.2 Bahnstromversorgung
3.3 Sicherungsanlagen

4 Betrieb:
4.1 Interoperabilität, Normen und Zulassung
4.2 RAMS, LCC
4.3 Anwendungsbeispiele

Voraussichtlich ein oder zwei Gastreferate

Geplante Exkursionen:
Betriebsszentrale SBB, Zürich Flughafen
Reparatur und Unterhalt, SBB Zürich Altstetten
Fahrzeugfertigung, Stadler Bussnang

Lecture notes
Abgabe der Unterlagen (gegen eine Schutzgebühr) zu Beginn des Semesters. Rechtzeitig eingeschriebene Teilnehmer können die Unterlagen auf Wunsch und gegen eine Zusatzgebühr auch in Farbe beziehen.

Prerequisites / notice

Dozent:
Dr. Markus Meyer, Emkamatik GmbH

Voraussichtlich ein oder zwei Gastvorträge von anderen Referenten.

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Critical Thinking

363-1047-00L Urban Systems and Transportation W 3 credits 2G G. Loumeau

Abstract

This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

Objective

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.
The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today's economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

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Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.
This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical and geographical methods used in the process will be introduced and explained.
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

Agent-based modeling in general

MATSim

Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.

101-0499-00L Road Safety W 6 credits 4G M. Deublein, P. Eberling
Abstract
The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.

Objective
Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety

Content
Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy

Literature
Further literature: will be presented during the course

101-0491-10L Basics of Java and Best Practices for Scientific Computing W 1 credit 1U M. Balac
Abstract
This course provides an introduction to programming in Java, version control, and cloud computing.

Objective
At the end of the course, the students should
● Have acquired object-oriented programming skills with a focus on Java.
● Have an understanding of version control using git
● Have learned to deploy java applications on servers

Content
This course provides an introduction to object-oriented programming with Java. Four topics are covered:
● Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods, ...)
● Injection (traditional vs. Guice)
● Code versioning
● Java application deployment on servers

Literature
Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang

101-0549-00L Selected Topics on Legal Aspects in Civil Engineering W 3 credits 2G H. Briner, D. Trümper
Abstract
Basic knowledge in public and private law of civil engineering. Examples of the subjects treated: space management, protection of the environment, legal procedures, standards for building technology and contracts.

Objective
Part 1: The students shall acquire basic knowledge of the public law concerning civil engineering: space management, conception of buildings, protection of the environment, procedures
Part 2: The students shall acquire basic knowledge of the private law concerning civil engineering

Content
Teil 1: Jede Lektion behandelt für ein bestimmtes Stadium des Projekts ein Thema des öffentlichen Baurechts wie Bau- und Zonenordnungen, Quartierpläne, Umweltverträglichkeitsprüfungen, Baubewilligungsverfahren etc.
Teil 2: Grundzüge des privaten Baurechts wie Abnahme und Genehmigung von Bauwerken, Vollmacht des Architekten / Ingenieures zu Rechtshandlungen namens des Bauherrn, Mängelrüge im Bauwesen, Mehrheit ersatzpflichtiger Baubeteiligter, Generalunternehmervertrag, Haftung des Baumatериалvertäufers, Bauhandwerkerpfandrecht, Grundzüge der SIA-Norm 118, Baukonsortium, technische Normen, internationale Bauverträge, Architekten / Ingenieure als Gerichtsexperten, Aspekte des Bauzivilprozesses

Lecture notes
D. Trümper: Folien zu den Grundzügen des schweizerischen Bauvertragsrechts, Haftung- und Prozessrechts (Vorlesungsunterlage)
H. Briner: Tafeln zu den Grundzügen des öffentlichen Raumplanungs-, Bau- und Umweltrechts (Vorlesungsunterlage)

Literature
- Stöckli P./Siegenthaler Th. (Hrsg.) Die Planerverträge, Schulthess 2013
- Gauch Peter, Werkvertrag. 5. Auflage, Schulthess 2011

101-0492-00L Microscopic Modelling and Simulation of Traffic Operations W 3 credits 2G M. Makridis
Abstract
The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies. The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.
Objective

The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:
- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.),
- Design a road transport network inside the simulation software,
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network,
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure,
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:

1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:
1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibration and validation of the simulation model.
3) Redesigning/ extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and present) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Lecture notes

The lecture notes and additional handouts will be provided before the lectures.

Additional literature recommendations will be provided at the lectures.

Literature

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

Further literature: will be presented during the course
Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics?

### Systems Dynamics and Complexity

**Abstract**

Finding solutions: what is complexity, problem solving cycle.

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption.

**Objective**

A successful participant of the course is able to:

- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches
- apply the problem solving cycle as a systematic approach to identify problems and their solutions
- calculate project schedules according to the critical path method
- setup and run systems dynamics models by means of the Vensim software
- identify feedback cycles and reasons for unintended systems behavior
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics

**Content**

Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamical systems, and macroeconomic modeling.

The course is structured along three main tasks:

1. Finding solutions
2. Implementing solutions
3. Controlling solutions

**PART 1** introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

**PART 2** discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

**PART 3**, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see “Prerequisites”).

### Interdisciplinary Project Work

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

**Number** 363-0541-00L

**Title** Systems Dynamics and Complexity

**ECTS** 3 credits

**Hours** 3G

**Lecturers** F. Schweitzer

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**Number** 103-0020-00L

**Title** Interdisciplinary Project

**ECTS** 16 credits

**Hours** 34A

**Lecturers** K. W. Axhausen

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**Number** 103-0419-01

**Title** Railway Infrastructures 1 (FS)

**ECTS** 3 credits

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**Prerequisite:** 101-0419-01  Railway Infrastructures 1 (FS)
Students apply the full range of their previously learned theoretical and methodological skills to solve the task together in their project team. Working closely with representatives of the case study area (e.g. officials, the wider public, different experts and decision-makers), which changes annually, as well as other experts, through site visits, and through individual mentoring by the six RE&IS chairs, students work in a stimulating and motivating environment to solve real-world spatial challenges.

- The semester is structured through an intermediate and final presentation, bilateral discussions with the chairs involved as well as individual group mentoring. On these meetings, the work status has to be communicated with adequate representational means and is discussed with the professors, assistants and possibly external experts.

- The project begins with a site visit of the project area at the beginning of the semester and the identification as well as precise formulation of the issues and opportunities observed within the project area.

- The students work on a complex, rather rough task and define their exact objective independently on the basis of the as-is analysis. In the overall strategy, the future development direction for the project area is then determined and measures are formulated to steer the development in this direction. Within a focus area or focus topic, students further develop their project and deepen their overall strategy. They test and evaluate the impact of selected measures and finally reflect on their project, summarize the most important findings and make a recommendation formulated to decision-makers.

- The project gets developed in an interdisciplinary group of students. The internal structuring of the group and distribution of work is to be organised by the students themselves.

- The choice of software for the project development is up to the students. The software used should be applicable to data analysis, information processing, image production and word processing. This can include the Adobe programs such as InDesign, Illustrator or Photoshop, GIS, the Microsoft programs such as Word, PowerPoint or Excel, CAD, R, etc.)

### Master's Thesis

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
103-0010-10L | Master’s Thesis | O | 20 credits | 43D | Supervisors

*Only for Spatial Development and Infrastructure Systems MSc, Programme Regulations 2021.*

**Abstract**

Before starting the Master's thesis, students must have
a. obtained the Bachelor's degree;  
b. fulfilled all specified admission conditions, if any;  
c. acquired at least 90 credits in the Master's programme, including the credits in the mandatory courses and 12 credits in the area of the interdisciplinary project.

**Objective**

To work independently and to produce a scientifically structured work.

**Content**

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

### Master Studies (Programme Regulations 2009)

#### Major Courses

##### Major in Spatial and Landscape Development

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
---|---|---|---|---|---
103-0468-00L | Participatory Environmental Modeling | W | 3 credits | 2G |

*Does not take place this semester.*

**Abstract**

The lecture accompanies students into a participatory modelling process. We explore environmental topics such as urban agriculture or climate-resilient city. Students will get to know participatory modelling tools as well as concepts and approaches related to it. Students elaborate the processes from questions to interactive operational models.

**Objective**

In this course students will learn:

- The process of developing a model to address an environmental problem: from choosing an appropriate technique (Agent-based modelling, Bayesian Networks and System dynamics), to conceptualization and model building.

- Communication and facilitation skills to foster effective and legitimate collaboration with stakeholders.

Students then apply this knowledge and skills to a real-life case study, creating a model with stakeholders to address an environmental problem.
There are three books that will function as main reference literature throughout the course:

1. Concepts and Theories
2. Techniques and Technologies
3. Analytical Competencies
4. Decision-making
5. Media and Digital Technologies
6. Problem-solving
7. Project Management
8. Adaptability and Flexibility
9. Communication
10. Leadership and Responsibility
11. Self-presentation and Social Influence
12. Sensitivity to Diversity
13. Negotiation
14. Adaptable and Flexible
15. Cooperative and Teamwork
16. Customer Orientation
17. Leadership and Responsibility
18. Self-presentation and Social Influence
19. Sensitivity to Diversity
20. Negotiation

This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.

In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

1. The History and Theory of the City as Project
2. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
3. The Idea of the Polis: Rome, Greece and Beyond
4. The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
5. Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
6. Of Absolutism and Enlightenment: Baroque, Defense and Colonization
7. The City of Labor: Company Towns as Cross-Cultural Phenomenon
8. Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
9. Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
10. The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory additional reading.

These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript). Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

### Major in Transport Systems and Behaviour

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>363-0445-00L</td>
<td>Production and Operations Management</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>T. Netland, H. Franke</td>
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</tbody>
</table>

This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:

1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 1978 of 2416
The course covers the most fundamental strategic and tactical concepts in production and operations management (POM).

Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

Agent Based Modeling in Transportation

This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models’ current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.

Objectives
- At the end of the course, the students should:
  - have an understanding of agent-based modeling
  - have an understanding of MATSim
  - have an understanding of the process needed to set up an agent-based study
  - have practical experience of using MATSim to perform practical transportation studies

Content
This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:

1) introduction of agent-based modeling and its comparison to the traditional state of practice modeling
2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts
3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained.
4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report.

During the course, outside lecturers will give several lectures on using MATSim in practice (i.e., SBB).

Literature
Agent-based modeling in general

MATSim

Prerequisites / notice
Additional relevant readings, primarily scientific articles, will be recommended throughout the course.

Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended.
Content

Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy

Literature


Further literature: will be presented during the course

101-0492-00L Microscopic Modelling and Simulation of Traffic Operations

Abstract

The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies.

The aim is to provide the fundamentals for building a realistic traffic-engineering project from beginning to end.

Objective

The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication.

Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario.

Upon completion of the course, the students will:

- Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.).
- Design a road transport network inside the simulation software.
- Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network.
- Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure.
- Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.

Content

In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:

1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:

1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

Lecture notes

The lecture notes and additional handouts will be provided before the lectures.

Literature

Additional literature recommendations will be provided at the lectures.

Prerequisites / notice

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: not assessed

Social Competencies

- Cooperation and Teamwork: assessed

Personal Competencies

- Creative Thinking: assessed
- Critical Thinking: assessed

401-0647-00L Introduction to Mathematical Optimization

Abstract

Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

Objective

The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content

Topics covered in this course include:

- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature

Information about relevant literature will be presented during the course

Prerequisites / notice

This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

101-0491-10L Basics of Java and Best Practices for Scientific Computing

Abstract

This course provides an introduction to programming in Java, version control, and cloud computing.

Objective

At the end of the course, the students should:

- Have acquired object-oriented programming skills with a focus on Java.
- Have an understanding of version control using git.
- Have learned to deploy java applications on servers

Content

This course provides an introduction to object-oriented programming with Java. Four topics are covered:

- Basics of Java (objects, classes, interfaces, abstract classes, static classes, static methods, ...)
- Injection (traditional vs. Guice)
- Code versioning
- Java application deployment on servers

Literature

Intro to Java Programming, Comprehensive Version (10th Edition) by Y. Daniel Liang
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0258-00L</td>
<td>River Engineering</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>V. Weitbrecht, I. Schalko, K. Sperger</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td></td>
<td>At the end of the course, the students will be able to:</td>
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<td></td>
<td>• recall and describe the fundamentals of transport processes in rivers,</td>
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<td>• apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,</td>
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<td>• design and dimension river engineering works needed to influence the processes in watercourses, and</td>
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<td>• determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.</td>
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<td>In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.</td>
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<td>The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.</td>
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<td></td>
<td><strong>Lecture notes</strong></td>
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<td></td>
<td>Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<tr>
<td></td>
<td>1. «Flussbau» lecture notes of fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance)</td>
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<td></td>
<td>2. Erosion and Sedimentation; Pierre Y. Julien</td>
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<tr>
<td></td>
<td>3. River Mechanics; Pierre Y. Julien</td>
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<td></td>
<td><strong>Prerequisites / notice</strong></td>
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<tr>
<td></td>
<td>Recommended lectures: Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).</td>
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<td></td>
<td><strong>Fostered competencies</strong></td>
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<td></td>
<td><strong>Subject-specific Competencies</strong></td>
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<td></td>
<td>Concepts and Theories</td>
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<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<td><strong>Method-specific Competencies</strong></td>
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<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
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<td>Problem-solving</td>
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<td><strong>Social Competencies</strong></td>
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<td></td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
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<td><strong>Personal Competencies</strong></td>
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<td></td>
<td>Creative Thinking</td>
<td>not assessed</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Self-direction and Self-management</td>
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<tr>
<td>101-0469-00L</td>
<td>Road Safety</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>M. Deublein, P. Eberling</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>The collection and the methods of statistical and geographical analysis of road accidents are important fundamentals of this course. Safety Aspects in design of urban roads are discussed and measures for improving the safety situation are presented. Procedures of infrastructure safety management for administrations and police are another topic.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td></td>
<td>Imparting knowledge base about road safety and the event of accident, presenting possibilities to increase road safety</td>
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<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Accident origin, collection of road accidents, statistical (descriptive and multivariate, accident prediction models) and geographical analysis of road accidents, risk analysis and rehabilitation measures, road safety instruments for infrastructure with focus on road safety audit, Swiss and international transport policy</td>
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<tr>
<td></td>
<td><strong>Literature</strong></td>
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<td>Further literature: will be presented during the course</td>
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<tr>
<td>101-0492-00L</td>
<td>Microscopic Modelling and Simulation of Traffic Operations</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Makridis</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<td>The course introduces basics of microscopic modelling and simulation of traffic operations, including model design and development, calibration, validation, data analysis, identification of strategies for improving traffic flow performance, and evaluation of such strategies.</td>
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<td></td>
<td><strong>Objective</strong></td>
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<td>The objective of this course is to conduct a realistic traffic engineering project from beginning to end. The students will first familiarize themselves with microscopic traffic models. Students will work in groups on a project that includes a base scenario on a real traffic network. Throughout the semester, along with theoretical concepts, the students will build the base scenario (design, calibration and validation) and will develop alternative scenarios regarding modification on the infrastructure, simulation of in-vehicle technologies and vehicle-to-everything (V2X) communication. Simulations will be implemented in Aimsun software. The students will be asked to understand, analyze, interpret and present traffic properties. Evaluation of alternative scenarios over the same network will be performed. Finally, students will be asked to design, implement, analyze and present a novel proposal, which will be compared with the base scenario. Upon completion of the course, the students will:</td>
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<td>• Understand the basic models used in microsimulation software (car-following, lane changing, gap acceptance, give ways, on/off-ramps, etc.),</td>
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<td>• Design a road transport network inside the simulation software,</td>
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<td>• Understand the basics behind modeling traffic demand and supply, vehicle dynamics, performance indicators for evaluation and network design for a realistic road transport network,</td>
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<td>• Understand how to design a complete study, implement and validate it for planning purposes, e.g. creating a new road infrastructure,</td>
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<td></td>
<td>• Make valid and concrete engineering proposals based on the simulation model and alternative scenarios.</td>
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</tbody>
</table>
In this course, the students will first learn some microscopic modelling and simulation concepts, and then complete a traffic-engineering project with microscopic traffic simulator Aimsun. Microscopic modelling and simulation concepts will include:

1) Car following models
2) Lane change models
3) Calibration and validation methodology

Specific tasks for the project will include:

1) Building a model with the simulator Aimsun in order to replicate and analyze the traffic conditions measured/observed.
2) Calibrating and validating the simulation model.
3) Redesigning/extending the model to improve the traffic performance through Aimsun and with/without programming in Python or C++.

The course will be based on a project that each group of students will build (design, calibrate, analyze and presentation) across the semester. A mid-term and final presentation of the work will be asked from each group of students. It consists of weekly 2-hour lectures. The students work in pairs on a group project that completes in the end of the semester. The modelling software used is Aimsun and lectures (theory and hands on experience) are taking place in a computer room.

The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun/Python/C++ is helpful but not mandatory.

The lecture notes and additional handouts will be provided before the lectures.

Additional literature recommendations will be provided at the lectures.

Students need to know some basic road transport concepts. The course Road Transport Systems (Verkehr III), or simultaneously taking the course Traffic Engineering is encouraged. Previous experience with Aimsun is helpful but not mandatory.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
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<td></td>
<td>Problem-solving</td>
<td>not assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Cooperation and Teamwork</td>
<td>assessed</td>
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<td>Personal Competencies</td>
<td>Creative Thinking</td>
<td>assessed</td>
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<td></td>
<td>Critical Thinking</td>
<td>assessed</td>
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</tbody>
</table>

101-0419-02L  Railway Infrastructures 2  W  2 credits  2G  U. A. Weidmann, P. Güldenapfel, M. Kohler, M. J. Manhart

Abstract
Track geometry including calculation and measuring as well as related data systems; clearance profiles; interaction between track and vehicles, vehicle dynamics, stress; track construction including special features of railway bridges and tunnels; environmental aspects in track construction; track diagnostics and forecast; track maintenance and related methods

Objective
The lecture gives a deeper insight into track geometry including clearance profile, the interaction between track and vehicles as well as in construction and dimensioning of the track. Methods for the diagnosis of the state of the track and its forecast are shown. State-of-the-art maintenance strategies and technologies are presented.

Content
1 - Track geometry
Track geometry including calculation and measuring as well as related data systems; clearance profiles

2 - Interaction
Interaction between track and vehicles, vehicle dynamics

3 - Railway Track
Stress; track construction including special features of railway bridges and tunnels

4 - Environmental aspects in track construction
Fundamentals; noise protection; vibration protection

5 - Diagnostics, maintenance strategies
Track diagnostics and forecast; maintenance strategies

6 - Track maintenance
Fundamentals of track maintenance and related methods

Lecture notes
The slides will be made available.


Literature
A list with related technical literature will be handed out.

Prerequisites / notice
Prerequisite: 101-0419-01 Railway Infrastructures 1 (FS)

101-0187-00L  Structural Reliability and Risk Analysis  W  3 credits  2G  S. Marelli

Abstract
Structural reliability aims at quantifying the probability of failure of systems due to uncertainties in their design, manufacturing and environmental conditions. Risk analysis combines this information with the consequences of failure in view of optimal decision making. The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment.

Objective
The goal of this course is to provide the students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.
Content

Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro- codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FORM) and the first order reliability method (FORM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

Lecture notes

Slides of the lectures are available online every week. A printed version of the full set of slides is proposed to the students at the beginning of the semester.

Literature


S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-v0.92-107.

Prerequisites / notice

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>103-0010-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>24</td>
<td>51D</td>
<td>Supervisors</td>
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<tr>
<td></td>
<td>Only for Spatial Development and Infrastructure Systems</td>
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<td>MSc, Programme Regulations 2009.</td>
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</table>

Before starting the Master's thesis, students must have
a. obtained the Bachelor's degree;
b. fulfilled all specified admission conditions, if any;c. acquired at least 90 credits in the Master's programme, including the credits in the mandatory courses and 12 credits in the area of the interdisciplinary project.

Abstract

The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 16 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Objective

To work independently and to produce a scientifically structured work.

Content

The topics of the Master Thesis are published by the professors. The Topic can be set also in consultation between the student and the professor.

Electives

The entire course programs of ETH Zurich and University Zurich are open to the students to individual selection. The students have themselves to check whether they meet the admission requirements for a course.

Recommended Electives of Master Degree Programme

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0227-00L</td>
<td>Application Development in Cartography</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>L. Hurni</td>
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<td></td>
<td>Only for Spatial Development and Infrastructure Systems</td>
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</table>

Abstract

This course introduces concepts and techniques in 3D cartography and web application development. Practical experience will be gained in a map project.

Objective

Students acquire general knowledge about the foundations and best practices in 3D cartography and modern web application development. They learn to plan, design and implement an interactive and animated 3D web map.

Content

- 3D cartography
- Web mapping
- Data processing
- Animations and interactions
- Map and UI design
- Web application development
- Programming (JavaScript).

Lecture notes

Handouts of the lectures and exercise documents are available on Moodle.

Prerequisites / notice

Cartography II or Introduction to Web Cartography Part 1+2 (MOOC) or similar knowledge in mapping with JavaScript.

Fostered competencies

Subject-specific Competencies

Techniques and Technologies     assessed
Analytical Competencies         assessed
Media and Digital Technologies  assessed
Problem-solving                 assessed
Project Management              assessed

Method-specific Competencies

Cooperation and Teamwork        assessed

Social Competencies

Creative Thinking                assessed
Critical Thinking               assessed
Self-direction and Self-management assessed

Personal Competencies

Environmental Management        W 2 credits 2G R. Züst

151-0757-00L

Environmental Management

W 2 credits 2G R. Züst
Abstract
An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

Objective
Overview on environmental management and environmental management systems, general methods and principles.

Content
Introduction to environmental management / environmental management systems, energy and material flows; economical and ecological problems in industry; characterisation of an enterprise (incl. management handbook); structure and contents of an environmental management system; overview on the ISO 14001 ff. series; methods for environmental evaluation and assessment; integrated management systems; planning methodology and life-cycle-design design; planning example

Lecture notes
Information about environmental management and environmental management systems will be provided by a CD or mail.

Literature
A list with literatures and links will be provided

Prerequisites / notice
Delivery of a case study, worked out in groups. Language: Teaching in English on request.

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581-0703-03L Private Construction Law
Only for Civil Engineering BSc, Spatial Development and Infrastructure Systems MSc and UZH MNF
Geographie/Erdsystemwissenschaften.

Abstract
This class introduces to practice-relevant basics of construction and real estate law.

Objective
As future construction practitioners, students are able to recognise legal problems independently and in good time in their daily work and to initiate the right measures.

Content
Introduction (most important sources of construction and real estate law), SIA (Swiss Society of Engineers and Architects) Design Engineering Services Contract, SIA-Norm 118 (SIA General Terms and Conditions for Construction Services), liability of designers/civil engineers, construction insurance, property law for civil engineers, sale of land, contaminated sites, statutory mortgage for contractors, public procurement, litigation in construction and real estate, the civil engineer as expert, What else to know ...

Lecture notes
There are "Lecture Notes" (in German) for this course.

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401-0647-00L Introduction to Mathematical Optimization

Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

Content
Topics covered in this course include:
- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

Literature
Information about relevant literature will be given in the lecture.

Prerequisites / notice
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advance lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

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363-0445-00L Production and Operations Management

Abstract
This core course provides insights into the basic theories, principles, concepts, and techniques used to design, analyze, and improve the operational capabilities of an organization.

Objective
This course provides students with a broad theoretical basis for understanding, designing, analyzing, and improving manufacturing operations. After completing this course:
1. Students can apply key concepts of POM to detail an operations strategy.
2. Students can do simple forecasting of demand and plan the needed capacity to meet it.
3. Students can conduct process mapping analysis, use it to design and improve processes and layouts, and elaborate on the limitations of the chosen method.
4. Students can choose IT, OT, and automation technology for manufacturing applications.
5. Students can design information flows, manage master data, and use it to plan and control a factory.
6. Students can design material flows in and beyond factories.
7. Students can design performance management systems.
8. Students can select and use problem-solving tools to improve quality and productivity.
9. Additional skills: Students acquire experience in teamwork.

Content
Production and Operations Management (POM) is at the heart of any business. It is concerned with the business processes that transform input into output and deliver products and services to customers. Factory management is an important part of POM, but it is much more than what takes place inside the production facilities of companies like ABB, Boeing, BMW, LEGO, Nestlé, Roche, TESLA, and Toyota. Did you know that the largest portion of assets and employees in most organizations are engaged in the operations function? Although this course focuses on manufacturing, all types of organizations depend on their operational capabilities. With the ongoing globalization and digitization of manufacturing, POM has won a deserved status for providing a competitive advantage.

This course covers the following topics: Introduction to POM, Manufacturing strategy, Forecasting and capacity, Process design, Layout, Industry 4.0, Information flow, Material flow, Logistics/SCM Performance management, Performance improvement, Quality management, and Maintenance.

This course is administered via Moodle. The course is designed around five elements:
2. Video lectures. Short video lectures presenting basic POM concepts.
3. Class lectures. Deep-dives with case examples on select topics.
4. FactoryVR group assignment. FactoryVR allows students to visit factories virtually.
5. Quizzes. A few quizzes during the semester help students check their progress and prepare for the written exam.

Literature
Suggested literature is provided in the syllabus.
By the end of the course, students will be able to:

Assessed:

- Explain the main natural hazards, their processes and their importance in different contexts.
- Describe the likelihood, risk, and consequences of natural hazards and their management options.
- Identify and discuss the development of natural hazards in the context of climate change.
- Develop, formulate and present solutions to these challenges to a critical audience.

Literature


This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.

The course presents the underlying probabilistic modelling and computational methods for reliability and risk assessment. The goal of this course is to provide students with a thorough understanding of the key concepts behind structural reliability and risk analysis. After this course the students will have refreshed their knowledge of probability theory and statistics to model uncertainties in view of engineering applications. They will be able to analyze the reliability of a structure and to use risk assessment methods for decision making under uncertain conditions. They will be aware of the state-of-the-art computational methods and software in this field.

Literature


This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students' future design work.

In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

- 01. The History and Theory of the City as Project
- 02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
- 03. The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
- 04: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
- 05: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
- 06: The City of Labor: Company Towns as Cross-Cultural Phenomenon
- 07: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
- 08: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
- 09: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid
- 10: Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
- 11: The History and Theory of the City as Project

Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

A list of further recommended literature will be found within each chapter of the reader (Skript).

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management
Engineers are confronted every day to decision making under limited amount of information and uncertain conditions. When designing new structures and systems, the design codes such as SIA or Euro-codes usually provide a framework that guarantees safety and reliability. However the level of safety is not quantified explicitly, which does not allow the analyst to properly choose between design variants and evaluate a total cost in case of failure. In contrast, the framework of risk analysis allows one to incorporate the uncertainty in decision making.

The first part of the course is a reminder on probability theory that is used as a main tool for reliability and risk analysis. Classical concepts such as random variables and vectors, dependence and correlation are recalled. Basic statistical inference methods used for building a probabilistic model from the available data, e.g. the maximum likelihood method, are presented.

The second part is related to structural reliability analysis, i.e. methods that allow one to compute probabilities of failure of a given system with respect to prescribed criteria. The framework of reliability analysis is first set up. Reliability indices are introduced together with the first order-second moment method (FORM) and the first order reliability method (FOM). Methods based on Monte Carlo simulation are then reviewed and illustrated through various examples. By-products of reliability analysis such as sensitivity measures and partial safety coefficients are derived and their links to structural design codes is shown. The reliability of structural systems is also introduced as well as the methods used to reassess existing structures based on new information.

The third part of the course addresses risk assessment methods. Techniques for the identification of hazard scenarios and their representation by fault trees and event trees are described. Risk is defined with respect to the concept of expected utility in the framework of decision making. Elements of Bayesian decision making, i.e. pre-, post and pre-post risk assessment methods are presented.

The course also includes a tutorial using the UQLab software dedicated to real world structural reliability analysis.

### Literature

- S. Marelli, R. Schöbi, B. Sudret, UQLab user manual - Structural reliability (rare events estimation), Report UQLab-V0.92-107.

### Prerequisites / notice

Basic course on probability theory and statistics

### 363-0565-00L Principles of Macroeconomics

- **Abstract**: This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

- **Objective**: This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to everyday economic problems.

- **Content**: This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer. Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

- **Lecture notes**: The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

- **Literature**: The set-up of the course will closely follow the book of N. Gregory Mankiw and Mark P. Taylor (2020), Economics, Cengage Learning, Fifth Edition. This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

### Fostered competencies

- **Subject-specific Competencies**: Concepts and Theories - assessed, Techniques and Technologies - not assessed
- **Method-specific Competencies**: Analytical Competencies - assessed, Decision-making - not assessed, Media and Digital Technologies - not assessed, Problem-solving - assessed, Project Management - not assessed
- **Social Competencies**: Communication - not assessed, Cooperation and Teamwork - not assessed, Customer Orientation - not assessed, Leadership and Responsibility - not assessed, Self-presentation and Social Influence - assessed, Sensitivity to Diversity - not assessed, Negotiation - not assessed
- **Personal Competencies**: Adaptability and Flexibility - not assessed, Creative Thinking - not assessed, Critical Thinking - assessed, Integrity and Work Ethics - not assessed, Self-awareness and Self-reflection - not assessed, Self-direction and Self-management - not assessed

### 401-3901-00L Linear & Combinatorial Optimization

- **Abstract**: Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

- **Objective**: The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

Concepts and Theories

1. «Flussbau» lecture notes of Fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance).

Urban Design III

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

Analytical Competencies

Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Short practical exercises (voluntary) will be offered throughout the semester to improve the application of the learned subjects.

101-0258-00L River Engineering

Abstract

At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Lecture notes

1. «Flussbau» lecture notes of Fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance)

2. Erosion and Sedimentation; Pierre Y. Julien

3. River Mechanics; Pierre Y. Julien

Recommended lectures:

Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

052-0707-00L Urban Design III

Abstract

Students are introduced to a narrative of 'Urban Stories' through a series of three tools driven by social, governance, and environmental transformations in today's urbanization processes. Each lecture explores one city's spatial and organizational ingenuity born out of a particular place's realities, allowing students to transfer these inventions into a catalog of conceptual tools.
### Objective

How can students of architecture become active agents of change? What does it take to go beyond a building’s scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.

### Content

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

### Lecture notes

The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox ‘Reader’ with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings

### Literature

- Reading material will be provided throughout the semester.

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<th>103-0687-00L</th>
<th>Cadastral Systems</th>
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<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Conception, structure and impact of cadastral systems such as property cadastre, PLR-cadastre and related spatial data infrastructures (SDI) as well as their importance for civil society.</td>
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<td><strong>Content</strong></td>
<td>Origin and purpose of cadastral systems</td>
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<td>Importance of documentation of property information</td>
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<td>- Embedding cadastral data in the national spatial data infrastructure</td>
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<tr>
<td><strong>Literature</strong></td>
<td>Larson, G. (1991), Land Registration and Cadastral Systems: Tools for Land</td>
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<td>Adlington, G. (2021): Real Estate Registration and Cadastre - Practical Lessons and Experiences</td>
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<td><strong>Fostered competencies</strong></td>
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| Data: 01.11.2022 12:41 | Autumn Semester 2022 | Page 1988 of 2416 |
The literature will be made available at the beginning of the course.

### Lectures

Type 9R

**Systems Engineering**

**Title**

B. T. Adey

The weekly content is structured as follows:

1. Introduction – An introduction to System Engineering, a way of thinking that helps to engineer sustainable systems, i.e. ones that meet the needs of stakeholders in the short, medium and long term. A high-level overview of the main principles of System Engineering. An introduction to the example that we will be working with through most of the course. The expectations of your efforts throughout the semester.
2. Situation analysis – How to structure the large amount of information that is often associated with attempting to modify complex systems.
3. Goals and constraints – How to set goals and constraints to identify the best solutions as clearly as possible.
4. Generation of possible solutions – How to generate possible solutions to problems, considering multiple stakeholders.
5. Analysis – 1/5 – The principles of net-benefit maximization and a series of methods that range from qualitative and approximate to quantitative and exact, including pairwise comparison, elimination, display, weighting, and expected value.
6. Analysis – 2/5 – The idea behind the supply and demand curves and revealed preference methods.
7. Analysis – 3/5 – The concept of equivalence, including the time value of money, interest, life times and terminal values.
8. Analysis – 4/5 – The relationship between net-benefit and the benefit-cost ratio. How incremental cost benefit analysis can be used to determine the maximum net benefit. Marginal rates of return and internal rates of return.
9. Analysis – 5/5 – How to consider multiple possible futures and use simple rules to help pick optimal solutions and to determine the value of more information.
10. Evaluation of solutions – Regardless how sophisticated an analysis is, it requires that decision makers stand back and critically evaluate the results. This week we discuss the aspects of evaluating the results of an analysis.
11. Operations research – 1/4 – Once quantitative analysis is used it becomes possible to use operations research methods to analyse large numbers of possible solutions. This week we discuss linear programming and the simplex method.
13. Operations research – 3/4 – How to use operations research to solve problems that consist of discrete values, as well as how to exploit the structure of networks to find optimal solutions to network problems.
14. Operations research – 4/4 – How to set up and solve problems when there are multiple objectives.

The course uses a combination of qualitative and quantitative approaches. The quantitative analyses requires the use of Excel. An introduction to Excel will be provided in one of the help sessions.

### Lecture notes

The script for the original course is in German. The English material that can be used for the virtual course is:


### Literature

The literature will be made available at the beginning of the course.
### Fostered competencies

#### Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

#### Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

#### Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

#### Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

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### 101-0515-AAL Project Management

**Enrolment** ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

#### Abstract
General introduction to the development, the lifecycle and the characteristics of projects. Introduction to, and experience with, the methods and tools to help with the preparation, evaluation, organisation, planning, controlling and completion of projects.

#### Objective
To introduce the methods and tools of project management. To impart knowledge in the areas of project organisation and structure, project planning, resource management, project controlling and on team leadership and team work.

#### Content
- From strategic planning to implementation (Project phases, goals, constraints, and feasibility)
- Project leadership (Leadership, Teams)
- Project organization (Structure)
- Project planning (Schedule, cost and resource planning)
- Project controlling
- Risk and Quality Management
- Project completion

### 103-0313-AAL Spatial Planning and Landscape Development

**Enrolment** ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

#### Abstract
The lecture introduces into the main-features of spatial planning. Attended will be the subjects of planning as a national responsibility, instruments of spatial planning, techniques for problem solving in spatial planning and the Swiss concept for regional planning.

#### Objective
- To get to know the interaction between the community and our living space and their resulting conflicts.
- Link theory and practice in spatial planning.
- To get to know instruments and facilities to process problems in spatial planning.

### 103-0414-AAL Transport Basics

**Enrolment** ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

#### Objective
- Introduction to the fundamentals of transportation
- Developing an understanding of the interactions between land use and transportation
- Introduction to the dynamics of transport systems: daily patterns and historical developments

#### Content
- Accessibility
- Equilibrium in transport networks
- Fundamental transport models
- Traffic flow and control
- Vehicle dynamics on rail and road
- Transport modes and supply patterns
- Time tables

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**Spatial Development and Infrastructure Systems Master - Key for Type**

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<tr>
<th>Key</th>
<th>Description</th>
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<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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</table>
### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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</tr>
</tbody>
</table>

**ECTS** European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
Computational Science and Engineering Bachelor

First Year Compulsory Courses

First Year Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0151-00L</td>
<td>Linear Algebra</td>
<td>O</td>
<td>5 credits</td>
<td>3V+2U</td>
<td>V. C. Gradinaru</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Contents: Linear systems - the Gaussian algorithm, matrices - LU decomposition, determinants, vector spaces, least squares - QR decomposition, linear maps, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Einführung in die Lineare Algebra für Ingenieure unter Berücksichtigung numerischer Aspekte</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>eigenes Aufschrift und K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, S. Auflage 2002</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>K. Nipp / D. Stoffer, Lineare Algebra, vdf Hochschulverlag, S. Auflage 2002</td>
</tr>
<tr>
<td></td>
<td>Fostered competencies</td>
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<td></td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td></td>
<td>Method-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td></td>
<td>Decision-making</td>
</tr>
<tr>
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<td>Social Competencies</td>
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<td>Communication</td>
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<tr>
<td></td>
<td>Personal Competencies</td>
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<td></td>
<td>Creative Thinking</td>
</tr>
</tbody>
</table>

252-0025-01L Discrete Mathematics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0025-01L</td>
<td>Discrete Mathematics</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>U. Maurer</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Content: Mathematical reasoning and proofs, abstraction, Sets, relations (e.g. equivalence and order relations), functions, (un-)countability, number theory, algebra (groups, rings, fields, polynomials, subalgebras, morphisms), logic (propositional and predicate logic, proof calculi).</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The primary goals of this course are (1) to introduce the most important concepts of discrete mathematics, (2) to understand and appreciate the role of abstraction and mathematical proofs, and (3) to discuss a number of applications, e.g. in cryptography, coding theory, and algorithm theory.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>See course description.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
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<td>See course description.</td>
</tr>
</tbody>
</table>

Computer Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0856-00L</td>
<td>Computer Science</td>
<td>O</td>
<td>6 credits</td>
<td>2V+2U+1P</td>
<td>F. O. Friedrich Wicker, R. Sasse</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The course covers the fundamental concepts of computer programming with a focus on systematic algorithmic problem solving. Taught language is C++. No programming experience is required.</td>
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<tr>
<td></td>
<td>Objective</td>
<td></td>
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<td></td>
<td>Primary educational objective is to learn programming with C++. After having successfully attended the course, students have a good command of the mechanisms to construct a program. They know the fundamental control and data structures and understand how an algorithmic problem is mapped to a computer program. They have an idea of what happens &quot;behind the scenes&quot; when a program is translated and executed. Secondary goals are an algorithmic computational thinking, understanding the possibilities and limits of programming and to impart the way of thinking like a computer scientist.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
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<td></td>
<td>The course covers fundamental data types, expressions and statements, (limits of) computer arithmetic, control statements, functions, arrays, structural types and pointers. The part on object orientation deals with classes, inheritance and polymorphism; simple dynamic data types are introduced as examples. In general, the concepts provided in the course are motivated and illustrated with algorithms and applications.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>English lecture notes will be provided during the semester. The lecture notes and the lecture slides will be made available for download on the course web page. Exercises are solved and submitted online.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>Bjarne Stroustrup: Einführung in die Programmierung mit C++, Pearson Studium, 2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Andrew Koenig and Barbara E. Moc: Accelerated C++, Addison-Wesley, 2000</td>
</tr>
</tbody>
</table>

First Year Examination Block 2

Analysis I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0231-10L</td>
<td>Analysis 1</td>
<td>O</td>
<td>8 credits</td>
<td>4V+3U</td>
<td>T. Rivière</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Students in BSc EEIT may instead register for 401-1261-07L Analysis I: One Variable (for BSc Mathematics, BSc Physics and BSc Interdisciplinary Science (Phys Chem)) and take the performance assessment of the corresponding two-semester course. Students in BSc EEIT who wish to register for 401-1261-07L/401-1262-07L Analysis I: One Variable/Analysis II: Several Variables instead of 401-0231-10L/401-0232-10L Analysis I/Analysis 2 must get in touch with the Study Administration before the registration.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Reelle und komplexe Zahlen, Grenzwerte, Folgen, Reihen, Potenzreihen, stetige Abbildungen, Differential- und Integralequationen einer Variablen, Einführung in gewöhnliche Differentialgleichungen</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>Christian Blatter: Ingenieur-Analyse (Kapitel 1-4)</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>Konrad Koenigsberger, Analyse I. Christian Blatter, Analyse I.</td>
</tr>
</tbody>
</table>

Physics I

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0043-00L</td>
<td>Physics I</td>
<td>O</td>
<td>4 credits</td>
<td>3V+1U</td>
<td>S. P. Quanz</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Introduction to the concepts and tools in physics with the help of demonstration experiments: mechanics of point-like and ridged bodies, periodic motion and mechanical waves.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The concepts and tools in physics, as well as the methods of an experimental science are taught. The student should learn to identify, communicate and solve physical problems in his/her own field of science.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>Mechanics (motion, Newton's laws, work and energy, conservation of momentum, rotation, gravitation, fluids) Periodic Motion and Waves (periodic motion, mechanical waves, acoustics).</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>The lecture follows the book &quot;Physics&quot; by Paul A. Tipler.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>Paul A. Tipler and Gene P. Mosca, Physics (for Scientists and Engineers), W. H. Freeman and Company</td>
</tr>
</tbody>
</table>

Basic Courses
## Analysis 3

**Number:** 401-0353-00L  
**Title:** Analysis 3  
**Type:** O  
**ECTS:** 4 credits  
**Hours:** 2V+2U  
**Lecturers:** M. Iacobelli

### Abstract
In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.

### Objective
The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.

### Content
1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)

2.) Quasilinear first order PDEs  
- Solution with the method of characteristics  
- Conservation laws

3.) Hyperbolic PDEs  
- wave equation  
- d’Alembert formula in (1+1)-dimensions  
- method of separation of variables

4.) Parabolic PDEs  
- heat equation  
- maximum principle  
- method of separation of variables

5.) Elliptic PDEs  
- Laplace equation  
- maximum principle  
- method of separation of variables  
- variational method

### Literature

### Prerequisites / notice
Prerequisites: Analysis I and II, Fourier series (Complex Analysis)

---

## Introduction to Mathematical Optimization

**Number:** 401-0647-00L  
**Title:** Introduction to Mathematical Optimization  
**Type:** O  
**ECTS:** 5 credits  
**Hours:** 2V+1U  
**Lecturers:** D. Adjiashvili

### Abstract
Introduction to basic techniques and problems in mathematical optimization, and their applications to a variety of problems in engineering.

### Objective
The goal of the course is to obtain a good understanding of some of the most fundamental mathematical optimization techniques used to solve linear programs and basic combinatorial optimization problems. The students will also practice applying the learned models to problems in engineering.

### Content
Topics covered in this course include:

- Linear programming (simplex method, duality theory, shadow prices, ...).
- Basic combinatorial optimization problems (spanning trees, shortest paths, network flows, ...).
- Modelling with mathematical optimization: applications of mathematical programming in engineering.

### Literature
Information about relevant literature will be given in the lecture.

### Prerequisites / notice
This course is meant for students who did not already attend the course "Mathematical Optimization", which is a more advanced lecture covering similar topics. Compared to "Mathematical Optimization", this course has a stronger focus on modeling and applications.

---

## Numerical Methods for CSE

**Number:** 401-2673-00L  
**Title:** Numerical Methods for CSE  
**Type:** O  
**ECTS:** 9 credits  
**Hours:** 2V+2U+4P  
**Lecturers:** R. Hiptmair

### Abstract
The course gives an introduction into fundamental techniques and algorithms of numerical mathematics which play a central role in numerical simulations in science and technology. The course focuses on fundamental ideas and algorithmic aspects of numerical methods. The exercises involve actual implementation of numerical methods in C++.

### Objective
* Knowledge of the fundamental algorithms in numerical mathematics  
* Knowledge of the essential terms in numerical mathematics and the techniques used for the analysis of numerical algorithms  
* Ability to choose the appropriate numerical method for concrete problems  
* Ability to interpret numerical results  
* Ability to implement numerical algorithms efficiently

### Content
* Computing with Matrices and Vectors  
* Direct Methods for linear systems of equations  
* Least Squares Techniques  
* Data Interpolation and Fitting  
* Iterative Methods for non-linear systems of equations  
* Filtering Algorithms  
* Approximation of Functions  
* Numerical Quadrature

### Lecture notes
Lecture materials (PDF documents and codes) will be made available to the participants through the course web page, whose address will be announced in the beginning of the course.

### Literature


M. Hanke-Bourgeois "Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens", BG Teubner, 2002

P. Deuflhard and A. Hohmann, "Numerische Mathematik I", DeGruyter, 2002

### Prerequisites / notice
The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Knowledge of C++ is taken for granted.
Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td></td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Concepts and Theories assessed
Techniques and Technologies assessed
Analytical Competencies assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

>>> Block G2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2813-00L</td>
<td>Programming Techniques for Scientific Simulations I</td>
<td>O</td>
<td>5 credits</td>
<td>4G</td>
<td>R. Käppeli</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture provides an overview of programming techniques for scientific simulations. The focus is on basic and advanced C++ programming techniques and scientific software libraries. Based on an overview over the hardware components of PCs and supercomputer, optimization methods for scientific simulation codes are explained.</td>
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<tr>
<td>Objective</td>
<td>The goal of the course is that students learn basic and advanced programming techniques and scientific software libraries as used and applied for scientific simulations.</td>
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</tr>
<tr>
<td>252-0061-00L</td>
<td>Systems Programming and Computer Architecture</td>
<td>O</td>
<td>7 credits</td>
<td>4V+2U</td>
<td>T. Roscoe, A. Klimovic</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to systems programming.  C and assembly language, floating point arithmetic, basic translation of C into assembler, compiler optimizations, manual optimizations. How hardware features like superscalar architecture, exceptions and interrupts, caches, virtual memory, multicore processors, devices, and memory systems function and affect correctness, performance, and optimization.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The course objectives are for students to:</td>
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</tr>
<tr>
<td></td>
<td>1. Develop a deep understanding of, and intuition about, the execution of all the layers (compiler, runtime, OS, etc.) between programs in high-level languages and the underlying hardware: the impact of compiler decisions, the role of the operating system, the effects of hardware on code performance and scalability, etc.</td>
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<td>2. Be able to write correct, efficient programs on modern hardware, not only in C but high-level languages as well.</td>
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<td>3. Understand Systems Programming as a complement to other disciplines within Computer Science and other forms of software development.</td>
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<tr>
<td></td>
<td>This course does not cover how to design or build a processor or computer.</td>
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<tr>
<td>Content</td>
<td>This course provides an overview of &quot;computers&quot; as a platform for the execution of (compiled) computer programs. This course provides a programmer’s view of how computer systems execute programs, store information, and communicate. The course introduces the major computer architecture structures that have direct influence on the execution of programs (processors with registers, caches, other levels of the memory hierarchy, supervisor/kernel mode, and I/O structures) and covers implementation and representation issues only to the extent that they are necessary to understand the structure and operation of a computer system.</td>
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<td>The course attempts to expose students to the practical issues that affect performance, portability, security, robustness, and extensibility. This course provides a foundation for subsequent courses on operating systems, networks, compilers and many other courses that require an understanding of the system-level issues. Topics covered include: machine-level code and its generation by optimizing compilers, address translation, input and output, trap/event handlers, performance evaluation and optimization (with a focus on the practical aspects of data collection and analysis).</td>
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<tr>
<td>Lecture notes</td>
<td>- C programming</td>
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<tr>
<td></td>
<td>- Integers</td>
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<tr>
<td></td>
<td>- Pointers and dynamic memory allocation</td>
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<tr>
<td></td>
<td>- Basic computer architecture</td>
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<td></td>
<td>- Compiling C control flow and data structures</td>
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<td></td>
<td>- Code vulnerabilities</td>
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<td></td>
<td>- Implementing memory allocation</td>
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<td></td>
<td>- Linking</td>
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<tr>
<td></td>
<td>- Floating point</td>
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<tr>
<td></td>
<td>- Optimizing compilers</td>
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<tr>
<td></td>
<td>- Architecture and optimization</td>
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<tr>
<td></td>
<td>- Caches</td>
<td></td>
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<tr>
<td></td>
<td>- Exceptions</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- Virtual memory</td>
<td></td>
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<tr>
<td></td>
<td>- Multicore</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- Devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>The course is based in part on &quot;Computer Systems: A Programmer's Perspective&quot; (3rd Edition) by R. Bryant and D. O'Hallaron, with additional material.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>252-0029-00L Parallel Programming</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>252-0028-00L Design of Digital Circuits</td>
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</tbody>
</table>

>>> Block G3

All course units within Block G3 are offered in the spring semester.

>>> Block G4

All course units within Block G4 are offered in the spring semester.
## Core Courses from Group I (Modules)

### Module A

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-0107-20L</td>
<td>High Performance Computing for Science and Engineering (HPCSE) I</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>S. M. Martin, J. H. Walther</td>
</tr>
</tbody>
</table>

**Abstract**

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.

**Content**

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

**Lecture notes**

https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/ Class notes, handouts

**Literature**

- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

**Prerequisites / notice**

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercices and exams will be designed using C++.

### Module B

**Number**

263-2800-00L

**Title**

Design of Parallel and High-Performance Computing

**Type**

W

**ECTS**

9 credits

**Hours**

3V+2U+3A

**Lecturers**

T. Hoefler, M. Püschel

**Abstract**

Advanced topics in parallel and high-performance computing.

**Objective**

Understand concurrency paradigms and models from a higher perspective and acquire skills for designing, structuring and developing possibly large parallel high-performance software systems. Become able to distinguish parallelism in problem space and in machine space. Become familiar with important technical concepts and with concurrency folklore.

**Content**

We will cover all aspects of high-performance computing ranging from architecture through programming up to algorithms. We will start with a discussion of caches and cache coherence in practical computer systems. We will dive into parallel programming concepts such as memory models, locks, and lock-free. We will cover performance modeling and parallel design principles as well as basic parallel algorithms.

**Prerequisites / notice**

This course is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)* and "Algorithmen und Datenstrukturen (algorithm and data structures)* or equivalent courses.

### Module C

**Number**

151-0107-20L

**Title**

High Performance Computing for Science and Engineering (HPCSE) I

**Type**

W

**ECTS**

4 credits

**Hours**

4G

**Lecturers**

S. M. Martin, J. H. Walther

**Abstract**

This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance computing (HPC) architectures.
Content

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/

Class notes, handouts

Literature
- An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

Prerequisites / notice

Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++. The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

Core Courses from Group II

No offering in the Autumn Semester.

Fields of Specialization

Astrophysics

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>401-7851-00L</td>
<td>Theoretical Astrophysics (University of Zurich)</td>
<td>W</td>
<td>10 credits</td>
<td>4V+2U</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Abstract

This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content

This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

Literature

Course Materials:
1- The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
2- The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
3- Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
4- Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
5- Galactic Dynamics, James Binney and Scott Tremaine

Prerequisites / notice

This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

Prerequisites:
Introduction to Astrophysics
Mathematical Methods for the Physicist
Quantum Mechanics
(All preferred but not obligatory)

Prior Knowledge:
Mechanics
Quantum Mechanics and atomic physics
Thermodynamics
Fluid Dynamics
Electrodynamics

401-7855-00L | Computational Astrophysics (University of Zurich) | W    | 6 credits | 2V | L. M. Mayer |

Objective

Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes.
Content
1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

Literature
Galactic Dynamics (Binney & Tremaine, Princeton University Press),
Computer Simulation using Particles (Hockney & Eastwood CRC press),
Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

Prerequisites / notice
Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

►► Physics of the Atmosphere

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<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>701-0023-00L</td>
<td>Atmosphere</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>E. Fischer, T. Peter</td>
</tr>
</tbody>
</table>

Abstract
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Objective
Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Content
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Lecture notes
Written information will be supplied.

Literature

►► Chemistry

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<th>Number</th>
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<tbody>
<tr>
<td>529-0004-01L</td>
<td>Classical Simulation of (Bio)Molecular Systems</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>P. H. Hünenberger, J. Dolenc, S. Riniker</td>
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</tbody>
</table>

Abstract
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective
Introduction to classical (atomic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content
Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Lecture notes
The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Literature
See: www.csms.ethz.ch/education/CSBMS

Prerequisites / notice
Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

►► Fluid Dynamics

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<th>Number</th>
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<tbody>
<tr>
<td>151-0103-00L</td>
<td>Fluid Dynamics II</td>
<td>W</td>
<td>3 credits</td>
<td>2V+1U</td>
<td>P. Jenny</td>
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</tbody>
</table>

Abstract

Objective
Expand basic knowledge of fluid dynamics.

Content

Lecture notes
Lecture notes are available in German. (See also info on literature below.)

Literature
Relevant chapters (corresponding to lecture notes) from the textbook


Prerequisites / notice
Analysis I/II, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas

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<th>Number</th>
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<tr>
<td>151-0709-00L</td>
<td>Stochastic Methods for Engineers and Natural Scientists</td>
<td>W</td>
<td>4 credits</td>
<td>4G</td>
<td>D. W. Meyer-Massetti</td>
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</table>

Abstract
The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent and subsurface flows. Moreover, mathematical techniques are presented that are used to quantify uncertainty in various engineering applications.

Objective
By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover, you should be able to develop basic stochastic models of such systems.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 1997 of 2416
Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Itô calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
- Statistical tests for means and goodness-of-fit

Lecture notes
Detailed lecture notes will be provided.

Literature
Some textbooks related to the material covered in the course:

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

151-0125-00L Hydrodynamics and Cavitation

Objective
The main learning objectives of this course are:
1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify hydrodynamic instabilities and discuss the stability region
3. Describe fragmentation of liquids
4. Explain tension, nucleation and phase-change in liquids.
5. Describe hydrodynamic cavitation and its consequences in physical terms.
6. Recognise experimental techniques and industrial and medical applications for cavitation.

Content
The course gives an overview on the following topics: hydrostatics, capillarity, hydrodynamic instabilities, fragmentation. Tension in liquids, phase change. Cavitation: single bubbles (nucleation, dynamics, collapse), cavitating flows (attached, cloud, vortex cavitation). Industrial applications and measurement techniques.

Lecture notes
Class notes and handouts

Literature
Literature will be provided in the course material.

Prerequisites / notice
Fluid dynamics I & II or equivalent

Systems and Control

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<tr>
<th>Number</th>
<th>Title</th>
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<tbody>
<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
</tbody>
</table>

Objective
Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.

Content

Literature

Prerequisites / notice
Prerequisites: Signal and Systems Theory II.

MATLAB is used for system analysis and simulation.

Robotics

Only one of the two course units
263-5902-00L Computer Vision resp.
227-0447-00L Image Analysis and Computer Vision
may be recognised for credits. More precisely, it is also not allowed to have recognised one course unit for the Bachelor's and the other course unit for the Master's degree.
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<tr>
<td>151-0601-00L</td>
<td>Theory of Robotics and Mechatronics</td>
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<td>3G</td>
<td>to be announced</td>
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<td><em>Does not take place this semester.</em></td>
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<td>manipulators, velocity kinematics, motion</td>
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<td>planning, trajectory generation, sensing, vision,</td>
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<td>and control.</td>
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<td>Robotics is often viewed from three perspectives:</td>
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<td>perception (sensing), manipulation (affecting</td>
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<td>changes in the world), and cognition</td>
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<td>(intelligence). Robotic systems integrate</td>
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<td>field, including rigid motions, homogeneous</td>
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<td>generation, sensing, vision, and control.</td>
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<tbody>
<tr>
<td>227-0447-00L</td>
<td>Image Analysis and Computer Vision</td>
<td>W</td>
<td>6</td>
<td>3V+1U</td>
<td>E. Konukoglu, F. Yu</td>
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</tbody>
</table>

**Abstract**


**Objective**

Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.

**Content**

This course aims at offering a self-contained account of computer vision and its underlying concepts, including the recent use of deep learning.

The first part starts with an overview of existing and emerging applications that need computer vision. It shows that the realm of image processing is no longer restricted to the factory floor, but is entering several fields of our daily life. First the interaction of light with matter is considered. The most important hardware components such as cameras and illumination sources are also discussed. The course then turns to image discretization, necessary to process images by computer. The next part describes necessary pre-processing steps, that enhance image quality and/or detect specific features. Linear and non-linear filters are introduced for that purpose. The course will continue by analyzing procedures allowing to extract additional types of basic information from multiple images, with motion and 3D shape as two important examples. Finally, approaches for the recognition of specific objects as well as object classes will be discussed and analyzed. A major part at the end is devoted to deep learning and AI-based approaches to image analysis. Its main focus is on object recognition, but also other examples of image processing using deep neural nets are given.

**Lecture notes**

Course material Script, computer demonstrations, exercises and problem solutions

Prerequisites:

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux. The course language is English.

**Prerequisites / notice**

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution. PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

The participation in the course is subject to the following condition: - Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

- Advanced Machine Learning
- Computational Intelligence Lab
- Introduction to Machine Learning
- Statistical Learning Theory
- Computational Statistics
- Probabilistic Artificial Intelligence

### Prerequisites / Literature

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<tr>
<th>Number</th>
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<th>Hours</th>
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<tbody>
<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>W</td>
<td>8</td>
<td>3V+2U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
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</tbody>
</table>

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to make sense of the computer vision literature.
4. To enable participants to make sense of the computer vision literature.

**Content**

- Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

**Prerequisites / notice**

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

---

### 263-5210-00L Probabilistic Artificial Intelligence

**Type** W

**ECTS** 8

**Hours** 3V+2U+2A

**Lecturers** A. Krause

**Abstract**

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

- How can we build systems that perform well in uncertain environments?
- How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules?
- How can we build systems that learn from experience in order to improve their performance?
- We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics.

**Content**

- Topics covered:
  - Probability
  - Probabilistic inference (variational inference, MCMC)
  - Bayesian learning (Gaussian processes, Bayesian deep learning)
  - Probabilistic planning (MDPs, POMDPs)
  - Multi-armed bandits and Bayesian optimization
  - Reinforcement learning

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

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### Computational Finance

**Number** 401-3913-01L

**Title** Mathematical Foundations for Finance

**Type** W

**ECTS** 4

**Hours** 3V+2U

**Lecturers** M. Schweizer

**Abstract**

First introduction to main modelling ideas and mathematical tools from mathematical finance

**Objective**

- Prerequisites and results from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitsrechnung").

**Content**

- Topics to be covered include
  - financial market models in finite discrete time
  - absence of arbitrage and martingale measures
  - valuation and hedging in complete markets
  - basics about Brownian motion
  - stochastic integration
  - stochastic calculus: Itô's formula, Girsanov transformation, Itô's representation theorem
  - Black-Scholes formula

**Prerequisites / notice**

See information on course homepage

**Fostered competencies**

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: not assessed

- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: not assessed

- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Critical Thinking: not assessed

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### Physics

**Number** 402-0809-00L

**Title** Introduction to Computational Physics

**Type** W

**ECTS** 8

**Hours** 2V+2U

**Lecturers** A. Adelmann

**Abstract**

This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.

**Objective**

- Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic systems. Students also learn how to implement their own numerical frameworks in Julia and how to use existing libraries to solve physical problems. In addition, students learn to distinguish between different numerical methods to apply them to solve a given physical problem.

**Content**

- Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.

**Lecture notes**

Lecture notes and slides are available online and will be distributed if desired.

**Literature**

Lecture recommendations and references are included in the lecture notes.

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.
Equations
Alternative course titles: "Numerical Analysis of Stochastic Ordinary Differential Equations" / "Computational Methods for Quantitative Finance: Monte Carlo and Sampling Methods"

Abstract
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content
Brownian motion and Lévy processes
Stochastic integration and stochastic calculus
Stochastic ordinary differential equations (SDEs)
Numerical approximations of SDEs
Stochastic simulation and Monte Carlo methods
Applications to computational finance: Option valuation

Lecture notes
There will be English, typed lecture notes for registered participants in the course.

Literature

Prerequisites / notice
Prerequisites:
Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.

a) mandatory courses:
Elementary Probability, Probability Theory I.

b) recommended courses:
Stochastic Processes.

Start of lectures: Wednesday September 21, 2022.

★★ Electromagnetics

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>227-2037-00L</td>
<td>Physical Modelling and Simulation</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>J. Smajic</td>
</tr>
</tbody>
</table>

Abstract
This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective
Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content
The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnet-mechanical and electromagnet-thermal analysis of MEMS. In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

★★ Geophysics

Recommended combinations:
Subject 1 + Subject 2
Subject 1 + Subject 3
Subject 2 + Subject 3
Subject 3 + Subject 4
Subject 5 + Subject 6 + Subject 8
Subject 4 + Subject 5
Subject 7 + Subject 8

★★★★ Geophysics: Subject 1

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<tr>
<td>651-4007-00L</td>
<td>Continuum Mechanics</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>T. Gerya</td>
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</tbody>
</table>

Abstract
In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth's mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications.
The goal of this course is to learn and understand few principal partial differential equations (conservation laws) that are applicable for analysing and modelling of any continuum including the Earth’s mantle, core, atmosphere and ocean. By the end of the course, students should be able to write, explain and analyse the equations and apply them for simple analytical cases. Numerical solving of these equations will be discussed in the Numerical Modelling I and II course running in parallel.

A provisional week-by-week schedule (subject to change) is as follows:

**Weeks 1.2: The continuity equation**
- Exercises: Computing the divergence of velocity field.

**Weeks 3.4: Density and gravity**
- Exercises: Computing density, thermal expansion and compressibility from an equation of state. Derivation of gravitational acceleration and its divergence from gravitational potential.

**Weeks 5.6: Stress and strain**

**Weeks 7.8: The momentum equation**

**Week 9: Viscous rheology of rocks**
- Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth's interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws.
- Exercises: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

**Weeks 10.11: The heat conservation equation**

**Week 12.13: Elasticity and plasticity**
- Exercise: compute viscoelastic stress evolution.

**Week 14: Fluid flow in deforming porous media. Darcy equation for fluid percolation. Derivation of Darcy equation from Stokes equation for channel flow. Dependence of permeability on porosity and grain size. Coupled hydro-mechanical momentum and continuity equations for solid matrix and percolating fluid. Fluid and solid Lagrangian reference frames.**

**Objective**

The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasise a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.
This course provides an overview on the most widely used seismological methods to image the Earth's interior with a focus on crustal and upper-mantle structures. Topics include controlled source methods such as refraction and wide-angle reflection, as well as passive body- and surface-wave based methods. The course will discuss the strengths and weaknesses of each method.


Weeks 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating theromechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the theromechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.
Objective

Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

Lecture notes

See http://jupiter.ethz.ch/~pij/FORTRAN/FortranClass.html

Fostered competencies

Subject-specific Competencies: Techniques and Technologies assessed
Method-specific Competencies: Media and Digital Technologies assessed
Problem-solving assessed

➡➡ Biology

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<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
</tbody>
</table>

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Content

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Prerequisites / notice

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

Literature


Objective

Computational Systems Biology

Abstract

Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modeling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

Content

The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

Prerequisites / notice

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.

The handout is available in German and English.

Connections to computer science and artificial intelligence are discussed, but the main focus of the course is on establishing the biological basis of computations in neurons.
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Content
- 1. Introduction
- 2. Automata and Languages
- 3. Smarter Automata
- 4. Specification Models
- 5. Stochastic Discrete Event Systems
- 6. Worst-Case Event Systems
- 7. Network Calculus

Lecture notes
Available

Literature
- Bertsekas, Data Networks
- Dimitri Bertsekas, Robert Gallager
- Borodin, Online Computation and Competitive Analysis
  Allan Borodin, Ran El-Yaniv
  Cambridge University Press, 1998
- Boudet, Network Calculus
  J.-Y. Le Boudec, P. Thiran
  Springer, 2001
- Cassandras, Introduction to Discrete Event Systems
  Christos Cassandras, Stéphane Lafortune
- Fiat, Online Algorithms: The State of the Art
  A. Fiat and G. Woeginger
- Hochbaum, Approximation Algorithms for NP-hard Problems (Chapter 13 by S. Irani, A. Karpin)
  D. Hochbaum
- Schickinger, Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
  T. Schickinger, A. Steger
  Springer, Berlin, 2001
- Sipser, Introduction to the Theory of Computation
  Michael Sipser.

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallelre Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.
Objective
Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

Content
This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Aneau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

Lecture notes
Textbook and all further documents in English.

Literature

Prerequisites / notice
Prerequisites:
Basics of digital circuits.

Examination:
In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English oder German.

Further details:
https://iis-students.ee.ethz.ch/lectures/vlsi-i/
This course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Abstract

Objective

Content

Literature

Lecture notes

This course acquaints students with core knowledge in computer graphics, image processing, multimedia and computer vision. Topics include: Graphics pipeline, perception and camera models, transformation, shading, global illumination, texturing, sampling, filtering, image representations, image and video compression, edge detection and optical flow.

Abstract

Objective

Content

Literature

Lecture notes

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Abstract

Objective

Content

Literature

Lecture notes

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

Abstract

Objective

Content

Prerequisites / notice

This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

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Objective

Content

Prerequisites / notice

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Objective

Content

Prerequisites / notice

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Prerequisites / notice

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This course provides the basics of relational databases from the perspective of the user.

We will discover why tables are so incredibly powerful to express relations, learn the SQL query language, and how to make the most of it. The course also covers support for data cubes (analytics).

**Objective**

Do you want to be able to query your own data productively and efficiently in your future semester projects, bachelor's thesis, master thesis, or PhD thesis? Are you looking for something beyond the Python+Pandas hype? This courses teaches you how to do so as well as the dos and don'ts.

This lesson is complementary with Big Data for Engineers as they cover different time periods of database history and practices -- you can take them in any order, even though it might be more enjoyable to take this lecture first.

After visiting this course, you will be capable to:

1. Explain, in the big picture, how a relational database works and what it can do in your own words.
2. Explain the relational data model (tables, rows, attributes, primary keys, foreign keys), formally and informally, including the relational algebra operators (select, project, rename, all kinds of joins, division, cartesian product, union, intersection, etc).
3. Perform non-trivial reading SQL queries on existing relational databases, as well as insert new data, update and delete existing data.
4. Design new schemas to store data in accordance to the real world's constraints, such as relationship cardinality.
5. Explain what bad design is and why it matters.
6. Adapt and improve an existing schema to make it more robust against anomalies, thanks to a very good theoretical knowledge of what is called "normal forms".
7. Understand how indices work (hash indices, B-trees), how they are implemented, and how to use them to make queries faster.
8. Access an existing relational database from a host language such as Java, using bridges such as JDBC.
9. Explain what data independence is all about and didn't age a bit since the 1970s.
10. Explain, in the big picture, how a relational database is physically implemented.
11. Know and deal with the natural syntax for relational data, CSV.
12. Explain the data cube model including slicing and dicing.
13. Store data cubes in a relational database.
14. Map cube queries to SQL.
15. Slice and dice cubes in a UI.

And of course, you will think that tables are the most wonderful object in the world.

**Content**

**Using a relational database**

1. Introduction
2. The relational model
3. Data definition with SQL
4. The relational algebra
5. Queries with SQL

**Taking a relational database to the next level**

6. Database design theory
7. Databases and host languages
8. Databases and host languages
9. Indices and optimization
10. Database architecture and storage

**Analytics on top of a relational database**

12. Data cubes

**Outlook**

14. Outlook

**Literature**

- Lecture material (slides).
- Book: "Database Systems: The Complete Book", H. Garcia-Molina, J.D. Ullman, J. Widom (It is not required to buy the book, as the library has it)

**Prerequisites / notice**

The lecture is hybrid, meaning you can attend with us in the lecture hall, or on Zoom, or watch the recordings on YouTube later. Exercise sessions are in presence.

For non-CS/DS students only, BSc and MSc
Elementary knowledge of set theory and logics
Knowledge as well as basic experience with a programming language such as Pascal, C, C++, Java, Haskell, Python.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3627-00L</td>
<td>High-Dimensional Statistics</td>
<td>W</td>
<td>4</td>
<td>P. L. Bühlmann</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>&quot;High-Dimensional Statistics&quot; deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Knowledge of methods and basic theory for high-dimensional statistical inference</td>
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<tr>
<td><strong>Content</strong></td>
<td>Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and $\ell_1$-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling</td>
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<tr>
<td><strong>Prerequisites</strong></td>
<td>Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).</td>
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<tr>
<th>Course Code</th>
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<th>Type</th>
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<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-4623-00L</td>
<td>Time Series Analysis</td>
<td>W</td>
<td>4</td>
<td>N. Meinshausen</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.</td>
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</tr>
<tr>
<td><strong>Content</strong></td>
<td>This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations. The key topics which will be covered as: Stationarity, Autocorrelation, Trend estimation, Elimination of seasonality, Spectral analysis, spectral densities, Forecasting, ARMA, ARIMA, Introduction into GARCH models</td>
<td></td>
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</tr>
<tr>
<td><strong>Literature</strong></td>
<td>The main reference for this course is the book &quot;Introduction to Time Series and Forecasting&quot;, by P. J. Brockwell and R. A. Davis</td>
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<tr>
<td><strong>Prerequisites</strong></td>
<td>Basic knowledge in probability and statistics</td>
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</table>

<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Type</th>
<th>Credits</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3901-00L</td>
<td>Linear &amp; Combinatorial Optimization</td>
<td>W</td>
<td>11</td>
<td>R. Zenklusen</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Mathematical treatment of optimization techniques for linear and combinatorial optimization problems. The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Key topics include: - Linear programming and polyhedra; - Flows and cuts; - Combinatorial optimization problems and polyhedral techniques; - Equivalence between optimization and separation.</td>
<td></td>
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</tr>
<tr>
<td><strong>Literature</strong></td>
<td>Solid background in linear algebra.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Prerequisites</strong></td>
<td>Former course title: Mathematical Optimization.</td>
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</tbody>
</table>
Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to assessed

Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on not assessed

not assessed

2V+3U assessed

Neuromorphic Engineering I S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications. not assessed

not assessed

not assessed

not assessed

not assessed

not assessed

not assessed

not assessed

not assessed

not assessed

not assessed

The teaching goals of this course are on five different levels:

A conceptual introduction to theoretical physics: Newtonian mechanics, central force problem, oscillations, Lagrangian mechanics, symmetries and conservation laws, Hamiltonian mechanics, canonical transformations, Hamilton-Jacobi equation, spinning top, relativistic space-time structure.

Objective

Fostered of their major.

Abstract

Information for UZH students:

Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-classes.html

Abstract

This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

Objective

Understanding of the characteristics of neuromorphic circuit elements.

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Literature

S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites / notice

Particular: The course is highly recommended for those who intend to take the spring semester course ‘Neuromorphic Engineering II’, that teaches the conception, simulation, and physical layout of such circuits with chip design tools.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

Transport Phenomena I J. Vermant

Phenomenological approach to “Transport Phenomena” based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

Objective

The teaching goals of this course are on five different levels:

(1) Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling, ...

(2) Ability to use the fundamental concepts in applications

(3) Insight into the role of boundary conditions (mainly part 2)

(4) Knowledge of a number of applications.

(5) Flavor of numerical techniques: finite elements and finite differences.

Content

Part 1 Approach to Transport Phenomena

Equilibrium Thermodynamics

Balance Equations

Forces and Fluxes

Applications

1. Measuring Transport Coefficients

2. Fluid mechanics

3. combined heat and flow

Lecture notes

This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostropic dynamics, understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation. Concepts and Theories

Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts.

Dynamics of Large-Scale Atmospheric Flow

M. Rotach

The objective of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that dynamical meteorology is concerned with the dynamical processes of the Earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of potential vorticity, Rossby waves, baroclinic instability. The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Content

- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes


Prerequisites / notice

Umwelt-Fluidodynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Literature


Fostered competencies

Subject-specific Competencies

Concepts and Theories

Methods-specific Competencies

Problem-solving

see also Fields of Specialization

Additional Electives from the Fields of Specialization (CSE Master)

Number Title Type ECTS Hours Lecturers
651-4053-05L Boundary Layer Meteorology W 4 credits 3G M. Rotach, P. Calanca

Abstract

The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective

Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts.

Content

- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes

available (i.e. in English)

Literature


Prerequisites / notice

Umwelt-Fluidodynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Number Title Type ECTS Hours Lecturers
701-1221-00L Dynamics of Large-Scale Atmospheric Flow W 4 credits 2V+1U H. Wernli, L. Papritz

Abstract

This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.

Objective

Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.

Content

Dynamical Meteorology is concerned with the dynamical processes of the Earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes

Dynamics of large-scale atmospheric flow

Literature

- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Prerequisites / notice

Physics I, II, Environmental Fluid Dynamics

Number Title Type ECTS Hours Lecturers
529-0003-01L Advanced Quantum Chemistry W 6 credits 3G M. Reiher, A. Baiardi

Abstract

Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer.

Examples are:

- Operators derived from principles of relativistic quantum mechanics
- Relativistic effects + methods of relativistic quantum chemistry
- Open-shell molecules + spin-density functional theory
- New electron-correlation theories

Objective

The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. As examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.
Content

1) Introductory lecture: basics of quantum mechanics and quantum chemistry
2) Einstein’s special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3) Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4) Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5) Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6) Relativistic effects in chemistry and the emergence of spin
7) Spin in density functional theory
8) New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group
9) Quantum chemistry without the Born-Oppenheimer approximation

Lecture notes
A set of detailed lecture notes will be provided, which will cover the whole course.

Literature

2) F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997
3) R. McWeeny: Methods of Molecular Quantum Mechanics, Academic Press, 1992

Note also the standard textbooks:
A) A. Szabo, N.S. Ostlund. Verlag, Dover Publications
B) I. N. Levine, Quantum Chemistry, Pearson

Prerequisites / notice
Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

151-0109-00L Turbulent Flows

W 4 credits 2V+1U  P. Jenny

Abstract

- Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scales. Homogeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows

Objective

Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling

Content

- Properties of laminar, transitional and turbulent flows.
- Origin and control of turbulence. Instability and transition.
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.
- Scales, homogeneous isotropic turbulence, energy spectrum.
- Turbulent free shear flows. Jet, wake, mixing layer.
- Wall-bounded turbulent flows.
- Turbulent flow computation and modeling.

Lecture notes
Lecture notes are available

Literature

151-0213-00L Fluid Dynamics with the Lattice Boltzmann Method

W 4 credits 3G  I. Karlin

Abstract

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Objective

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microflows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
Content
The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle’s distribution function, Liouville equation, entropy, ensembles; Kinetic theory; Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microflow:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; flows with phase transitions.

Abstract
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

Objective
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics
Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

Content
The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS.

Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available. Selected original and review papers are provided for some of the lectures on advanced topics. Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

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<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>636-0017-00L</td>
<td>Case Studies Seminar (Autumn Semester 2022)</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>V. Gradiarou, R. Hiptmaier</td>
</tr>
</tbody>
</table>

Case Studies
Invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list. Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.
Content

In the CSE Case Studies Seminar invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list (containing articles from, e.g., Nature, Science, Scientific American, etc.). If the underlying paper comprises more than 15 pages, two or three consecutive case studies presentations delivered by different students can be based on it. Consistency in layout, style, and contents of those presentations is expected.

Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

75% attendance and a short presentation on a published paper out of a list or on some own project are mandatory.

Students have to register their presentations online until the second Wednesday of the semester on https://rw.ethz.ch/the-programme/case-studies.html

The student talks will be grouped by subject, so we’ll decide the actual dates of the individual talks.

Students that realize that they will not fulfill this criteria have to contact the teaching staff or de-register before the end of semester from the Seminar if they want to avoid a “Fail” in their documents. Later de-registrations will not be considered.

Fostered competencies

Subject-specific Competencies
Techniques and Technologies
Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Social Competencies
Communication
Cooperation and Teamwork
Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MATH

Science in Perspective

see Science in Perspective: Language Courses ETH/UZH

Bachelor’s Thesis

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.

Number| Title| Type| ECTS| Hours| Lecturers |
---|---|---|---|---|---|
401-2000-00L| Scientific Works in Mathematics| O| 0 credits| | D. Possamaï |
401-2000-01L| Lunch Sessions – Thesis Basics for Mathematics Students| Z| 0 credits| | Speakers |
402-2000-00L| Scientific Works in Physics| W| 0 credits| | D. Kienzler |
Abstract

The BSc thesis concludes the curriculum. In their BSc thesis, students should demonstrate their ability to carry out independent, structured scientific work. The purpose of the BSc thesis is to deepen knowledge in a certain subject and to bring students into closer contact with applications in an existing computational group. The BSc thesis requires approximately 420 hours of work.

Objective

In their BSc thesis students should demonstrate their ability to carry out independent, structured scientific work. The purpose is to deepen knowledge in a certain subject and to enable students to collaborate in an existing scientific group to take a computational approach to problems encountered in applications.

Prerequisites / notice

The supervisor responsible for the Bachelor thesis defines the task and determines the start and the submission date. The Bachelor thesis concludes with a written report. The Bachelor thesis is graded.

Colloquia

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>401-5650-00L</td>
<td>Zurich Colloquium in Applied and Computational Mathematics</td>
<td>E-</td>
<td>0 credits</td>
<td>1K</td>
<td>R. Abgrall, R. Alaifari, H. Ammari, R. Hiptmair, S. Mishra, S. Sauter, C. Schwab</td>
</tr>
</tbody>
</table>

Computational Science and Engineering Bachelor - Key for Type

| O           | Compulsory                                   |
| W+         | Eligible for credits and recommended         |
| W          | Eligible for credits                         |

Key for Hours

| V          | lecture                                      |
| G          | lecture with exercise                        |
| U          | exercise                                     |
| S          | seminar                                      |
| K          | colloquium                                   |
| P          | practical/laboratory course                  |
| A          | independent project                          |
| D          | diploma thesis                               |
| R          | revision course / private study              |

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Computational Science and Engineering Master

**Core Courses**

In the 'core courses' subcategory, at least two course units must be successfully completed.

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>252-0535-00L</td>
<td>Advanced Machine Learning</td>
<td>W</td>
<td>10</td>
<td>3V+2U+4A</td>
<td>J. M. Buhmann, C. Cotrini Jimenez</td>
</tr>
</tbody>
</table>

**Abstract**

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real-world data.

**Content**

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

**Lecture notes**

No lecture notes, but slides will be made available on the course webpage.

**Literature**


**Prerequisites / notice**

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**Core Courses (continued)**

Only one of the two course units 263-5210-00L Probabilistic Artificial Intelligence resp. 252-0535-00L Advanced Machine Learning may be recognised for credits. More precisely, it is also not allowed to have recognised one course unit for the Bachelor's and the other course unit for the Master's degree.

For the category assignment take contact with the Study Administration (www.math.ethz.ch/studiensekretariat).

<table>
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<tr>
<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>263-5210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>W</td>
<td>8</td>
<td>3V+2U+2A</td>
<td>A. Krause</td>
</tr>
</tbody>
</table>

**Abstract**

This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

**Objective**

How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit "intelligent" behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from statistics, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.

**Content**

Topics covered:

- Probability
- Probabilistic inference (variational inference, MCMC)
- Bayesian learning (Gaussian processes, Bayesian deep learning)
- Probabilistic planning (MDPs, POMDPs)
- Multi-armed bandits and Bayesian optimization
- Reinforcement learning

**Prerequisites / notice**

Solid basic knowledge in statistics, algorithms and programming.

The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

**Fields of Specialization**

**Astrophysics**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-7851-00L</td>
<td>Theoretical Astrophysics (University of Zurich)</td>
<td>W</td>
<td>10</td>
<td>4V+2U</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>
This course covers the foundations of astrophysical fluid dynamics, the Boltzmann equation, equilibrium systems and their stability, the structure of stars, astrophysical turbulence, accretion disks and their stability, the foundations of radiative transfer, collisionless systems, the structure and stability of dark matter halos and stellar galactic disks.

Content
This course covers the foundations of astrophysical fluid dynamics, the theory of collisions and the Boltzmann equation, the notion of equilibrium systems and their stability, the structure of stars, the theory of astrophysical turbulence, the theory of accretion disks and their stability, the foundations of astrophysical radiative transfer, the theory of collisionless system, the structure and stability of dark matter halos and stellar galactic disks.

Literature
Course Materials:

1. The Physics of Astrophysics, Volume 1: Radiation by Frank H. Shu
2. The Physics of Astrophysics, Volume 2: Gas Dynamics by Frank H. Shu
3. Foundations of radiation hydrodynamics, Dimitri Mihalas and Barbara Weibel-Mihalas
4. Radiative Processes in Astrophysics, George B. Rybicki and Alan P. Lightman
5. Galactic Dynamics, James Binney and Scott Tremaine

Prerequisites / notice
This is a full black board ad chalk experience for students with a strong background in mathematics and physics.

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0023-00L</td>
<td>Computational Astrophysics</td>
<td>W</td>
<td>6</td>
<td>2V</td>
<td>L. M. Mayer</td>
</tr>
</tbody>
</table>

Objective
Acquire knowledge of main methodologies for computer-based models of astrophysical systems, the physical equations behind them, and train such knowledge with simple examples of computer programmes.

Content
1. Integration of ODE, Hamiltonians and Symplectic integration techniques, time adaptivity, time reversibility
2. Large-N gravity calculation, collisionless N-body systems and their simulation
3. Fast Fourier Transform and spectral methods in general
4. Eulerian Hydrodynamics: Upwinding, Riemann solvers, Limiters
5. Lagrangian Hydrodynamics: The SPH method
6. Resolution and instabilities in Hydrodynamics
7. Initial Conditions: Cosmological Simulations and Astrophysical Disks
8. Physical Approximations and Methods for Radiative Transfer in Astrophysics

Literature
Galactic Dynamics (Binney & Tremaine, Princeton University Press),
Computer Simulation using Particles (Hockney & Eastwood CRC press),
Targeted journal reviews on computational methods for astrophysical fluids (SPH, AMR, moving mesh)

Prerequisites
Some knowledge of UNIX, scripting languages (see www.physik.uzh.ch/lectures/informatik/python/ as an example), some prior experience programming, knowledge of C, C++ beneficial

Physics of the Atmosphere

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>651-4053-05L</td>
<td>Boundary Layer Meteorology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Rotach, P. Calanca</td>
</tr>
</tbody>
</table>

Abstract
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective
Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).
Seminar in Physics of the Atmosphere for CSE

H. Wernli


Classical Simulation of (Bio)Molecular Systems

Lecturers

Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.

Lecture notes

Dynamics of large-scale atmospheric flow

Literature

- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997

Prerequisites / notice

Physics I, II, Environmental Fluid Dynamics

Seminar cannot be taken. Please contact the lecturers (hanna.joos@env.ethz.ch) on time if you plan to take this seminar.

Seminar in Physics of the Atmosphere for CSE

W 4 credits

The process of writing a scientific proposal is introduced and the essential elements, including the peer review process, are outlined and class exercises train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work. An introduction to presentation skills is provided.

Objective

- scientific writing
- introduction to peer review process
- correction / feedback to the proposals of other participants
- presentation skills

Content

n this seminar, the process of writing a scientific proposal is introduced. The essential elements of a proposal, including the peer review process, are outlined and class exercises train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work. Furthermore, an introduction to presentation skills is provided.

Prerequisites / notice

In this seminar it is mandatory to write a proposal about an upcoming MSc thesis or semester project. If no such project is planned, this seminar cannot be taken. Please contact the lecturers (hanna.joos@env.ethz.ch) on time if you plan to take this seminar.

Chemistry

529-0004-01L

Classical Simulation of (Bio)Molecular Systems

W 6 credits

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Objective

Introduction to classical (atomistic) computer simulation of (bio)molecular systems, development of skills to carry out and interpret these simulations.

Content

Molecular models, classical force fields, configuration sampling, molecular dynamics simulation, boundary conditions, electrostatic interactions, analysis of trajectories, free-energy calculations, structure refinement, applications in chemistry and biology. Exercises: hands-on computer exercises for learning progressively how to perform an analyze classical simulations (using the package GROMOS).

Prerequisites / notice

Since the exercises on the computer do convey and test essentially different skills than those being conveyed during the lectures and tested at the oral exam, the results of the exercises are taken into account when evaluating the results of the exam (learning component, possible bonus of up to 0.25 points on the exam mark).

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

529-0003-01L

Advanced Quantum Chemistry

W 6 credits

Advanced, but fundamental topics central to the understanding of theory in chemistry and for solving actual chemical problems with a computer. Examples are:
- Operators derived from principles of relativistic quantum mechanics
- Relativistic effects + methods of relativistic quantum chemistry
- Open-shell molecules + spin-density functional theory
- New electron-correlation theories

Objective

The powerpoint slides of the lectures will be made available weekly on the website in pdf format (on the day preceding each lecture).

Content

- Operators derived from principles of relativistic quantum mechanics
- Relativistic effects + methods of relativistic quantum chemistry
- Open-shell molecules + spin-density functional theory
- New electron-correlation theories

Lecture notes

See: www.csms.ethz.ch/education/CSBMS

Prerequisites / notice

For more information about the lecture: www.csms.ethz.ch/education/CSBMS

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2020 of 2416
The aim of the course is to provide an in-depth knowledge of theory and method development in theoretical chemistry. It will be shown that this is necessary in order to be able to solve actual chemical problems on a computer with quantum chemical methods.

The relativistic re-derivation of all concepts known from (nonrelativistic) quantum mechanics and quantum-chemistry lectures will finally explain the form of all operators in the molecular Hamiltonian - usually postulated rather than deduced. From this, we derive operators needed for molecular spectroscopy (like those required by magnetic resonance spectroscopy). Implications of other assumptions in standard non-relativistic quantum chemistry shall be analyzed and understood, too. Examples are the Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions (Slater determinants). Overcoming these concepts, which are so natural to the theory of chemistry, will provide deeper insights into many-particle quantum mechanics. Also revisiting the workhorse of quantum chemistry, namely density functional theory, with an emphasis on open-shell electronic structures (radicals, transition-metal complexes) will contribute to this endeavor. It will be shown how these insights allow us to make more accurate predictions in chemistry in practice - at the frontier of research in theoretical chemistry.

**Content**

1. Introductory lecture: basics of quantum mechanics and quantum chemistry
2. Einstein's special theory of relativity and the (classical) electromagnetic interaction of two charged particles
3. Klein-Gordon and Dirac equation; the Dirac hydrogen atom
4. Numerical methods based on the Dirac-Fock-Coulomb Hamiltonian, two-component and scalar relativistic Hamiltonians
5. Response theory and molecular properties, derivation of property operators, Breit-Pauli-Hamiltonian
6. Relativistic effects in chemistry and the emergence of spin
7. Spin in density functional theory
8. New electron-correlation theories: Tensor network and matrix product states, the density matrix renormalization group
9. Quantum chemistry without the Born-Oppenheimer approximation

**Lecture notes**

A set of detailed lecture notes will be provided, which will cover the whole course.

**Literature**

2. F. Schwabl: Quantenmechanik für Fortgeschrittene (QM II), Springer-Verlag, 1997 [english version available: F. Schwabl, Advanced Quantum Mechanics]

**Prerequisites / notice**

Strongly recommended (preparatory) courses are: quantum mechanics and quantum chemistry

**Number** 401-5940-00L

**Seminar in Chemistry for CSE**

W 4 credits 2S 3 credits

P. H. Hünenberger, M. Reiher

The student will carry out a literature study on a topic of his or her liking (suggested by or in agreement with the supervisor) in the area of computer simulation in chemistry (Prof. Hünenberger) or of quantum chemistry (Prof. Reiher), the results of which are to be presented both orally and in written form.

For more information:

http://www.csms.ethz.ch/education/CSE_seminar.html

### Fluid Dynamics

**One of the course units 151-0103-00L Fluid Dynamics II 151-0109-00L Turbulent Flows**

**Number** 401-5940-00L

**Seminar in Chemistry for CSE**

W 4 credits 2S 3 credits

P. H. Hünenberger, M. Reiher

The student will carry out a literature study on a topic of his or her liking (suggested by or in agreement with the supervisor) in the area of computer simulation in chemistry (Prof. Hünenberger) or of quantum chemistry (Prof. Reiher), the results of which are to be presented both orally and in written form.

For more information:

http://www.csms.ethz.ch/education/CSE_seminar.html

#### Objective

The objective is to gain a thorough understanding of the fundamental concepts of fluid dynamics and their mathematical formulation. This includes an understanding of the behavior of fluids under various conditions and the ability to apply these concepts to solve practical problems.

#### Content

3. Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Meyer expansion, viscous effects.

#### Literature


#### Prerequisites / notice

Analysis I/II, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas

**Number** 401-5940-00L

**Seminar in Chemistry for CSE**

W 4 credits 2S 3 credits

P. H. Hünenberger, M. Reiher

The student will carry out a literature study on a topic of his or her liking (suggested by or in agreement with the supervisor) in the area of computer simulation in chemistry (Prof. Hünenberger) or of quantum chemistry (Prof. Reiher), the results of which are to be presented both orally and in written form.

For more information:

http://www.csms.ethz.ch/education/CSE_seminar.html

#### Fluid Dynamics

**One of the course units 151-0103-00L Fluid Dynamics II 151-0109-00L Turbulent Flows**

**Number** 401-5940-00L

**Seminar in Chemistry for CSE**

W 4 credits 2S 3 credits

P. H. Hünenberger, M. Reiher

The student will carry out a literature study on a topic of his or her liking (suggested by or in agreement with the supervisor) in the area of computer simulation in chemistry (Prof. Hünenberger) or of quantum chemistry (Prof. Reiher), the results of which are to be presented both orally and in written form.

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http://www.csms.ethz.ch/education/CSE_seminar.html

#### Objective

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#### Content

3. Compressible flows: isentropic flow along stream tube, normal and oblique shocks, Laval nozzle, Prandtl-Meyer expansion, viscous effects.

#### Literature


#### Prerequisites / notice

Analysis I/II, Knowledge of Fluid Dynamics I, thermodynamics of ideal gas
Abstract

- Laminar and turbulent flows, instability and origin of turbulence - Statistical description: averaging, turbulent energy, dissipation, closure problem - Scalings. Homogeneous isotropic turbulence, correlations, Fourier representation, energy spectrum - Free turbulence: wake, jet, mixing layer - Wall turbulence: Channel and boundary layer - Computation and modelling of turbulent flows

Objective

Basic physical phenomena of turbulent flows, quantitative and statistical description, basic and averaged equations, principles of turbulent flow computation and elements of turbulence modelling

Content

- Properties of laminar, transitional and turbulent flows.
- Origin and control of turbulence. Instability and transition.
- Statistical description, averaging, equations for mean and fluctuating quantities, closure problem.
- Scalings, homogeneous isotropic turbulence, energy spectrum.
- Turbulent free shear flows. Jet, wake, mixing layer.
- Wall-bounded turbulent flows.
- Turbulent flow computation and modeling.

Lecture notes

Lecture notes are available

Literature

The course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation. Stochastic Methods for Engineers and Natural Scientists

The course provides an introduction into stochastic methods that are applicable for example for the description and modeling of turbulent and subsurface flows. Moreover, mathematical techniques are presented that are used to quantify uncertainty in various engineering applications.

Some topics are illustrated with engineering applications.

Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0709-00L Stochastic Methods for Engineers and Natural Scientists

4 credits

Objective
By the end of the course you should be able to mathematically describe random quantities and their effect on physical systems. Moreover, you should be able to develop basic stochastic models of such systems.

Content
- Probability theory, single and multiple random variables, mappings of random variables
- Estimation of statistical moments and probability densities based on data
- Stochastic differential equations, Ito calculus, PDF evolution equations
- Monte Carlo integration with importance and stratified sampling
- Markov-chain Monte Carlo sampling
- Control-variate and multi-level Monte Carlo estimation
- Statistical tests for means and goodness-of-fit

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0125-00L Hydrodynamics and Cavitation

4 credits

Objective
This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

The main learning objectives of this course are:
1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify hydrodynamic instabilities and discuss the stability region
3. Describe fragmentation of liquids
4. Explain tension, nucleation and phase-change in liquids.
5. Describe hydrodynamic cavitation and its consequences in physical terms.
6. Recognise experimental techniques and industrial and medical applications for cavitation.

Content
The course gives an overview on the following topics: hydrostatics, capillarity, hydrodynamic instabilities, fragmentation. Tension in liquids, phase change. Cavitation: single bubbles (nucleation, dynamics, collapse), cavitating flows (attached, cloud, vortex cavitation). Industrial applications and measurement techniques.
Seminar in Fluid Dynamics for CSE

Enlarged knowledge and practical abilities in fundamentals and applications of Computational Fluid Dynamics

Contact Prof. P. Jenny before the beginning of the semester

Systems and Control

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>227-0103-00L</td>
<td>Control Systems</td>
<td>W</td>
<td>6</td>
<td>2V+2U</td>
<td>F. Dörfler</td>
</tr>
<tr>
<td>Abstract</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
<td>Objective</td>
<td>Study of concepts and methods for the mathematical description and analysis of dynamical systems. The concept of feedback. Design of control systems for single input - single output and multivariable systems.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Signal and Systems Theory II.</td>
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<tr>
<td>Lecture notes</td>
<td>Available on the course Moodle platform.</td>
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<tr>
<td>Fostered competencies</td>
<td>Sufficient mathematical maturity, in particular in linear algebra, analysis.</td>
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<tr>
<td>Subject-specific Competencies</td>
<td>Concepts and Theories assessed</td>
<td></td>
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<tr>
<td></td>
<td>Techniques and Technologies assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies assessed</td>
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<td></td>
<td>Problem-solving assessed</td>
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<tr>
<td>Personal Competencies</td>
<td>Creative Thinking not assessed</td>
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<tr>
<td></td>
<td>Critical Thinking not assessed</td>
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<td></td>
<td>Integrity and Work Ethics not assessed</td>
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</tbody>
</table>

Linear System Theory

The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and constructing proofs of properties of linear control systems.

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

MATLAB is used for system analysis and simulation.

Nonlinear Dynamics and Chaos I

Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

- Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
- Near equilibrium dynamics: Linear and Lyapunov stability.
- Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations.
- Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
- Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance.

The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

Signals and Systems

ECTS

Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

151-0532-00L

151-0575-01L
Abstract
Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals.

Objective
Master the basics of signals and systems. Apply this knowledge to problems in the homework assignments and programming exercise.

Content

Lecture notes
Lecture notes available on course website.

Prerequisites / notice
Control Systems I is helpful but not required.

---

151-0563-01L Dynamic Programming and Optimal Control

Objective
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature

Prerequisites / notice
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

---

252-0535-00L Advanced Machine Learning

Objective
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics experience for solving assignments.

Content
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:
- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

---

401-5850-00L Seminar in Systems and Control for CSE

Objective
PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

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Robotics

Only one of the two course units
263-5902-00L Computer Vision resp.
227-0447-00L Image Analysis and Computer Vision may be recognised for credits. More precisely, it is also not allowed to have recognised one course unit for the Bachelor's and the other course unit for the Master's degree.

Number Title Type ECTS Hours Lecturers
151-0601-00L Theory of Robotics and Mechatronics W 4 credits 3G to be announced

Abstract
This course provides an introduction and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.

Objective
Robotics is often viewed from three perspectives: perception (sensing), manipulation (affecting changes in the world), and cognition (intelligence). Robotic systems integrate aspects of all three of these areas. This course provides an introduction to the theory of robotics, and covers the fundamentals of the field, including rigid motions, homogeneous transformations, forward and inverse kinematics of multiple degree of freedom manipulators, velocity kinematics, motion planning, trajectory generation, sensing, vision, and control.
Objective

No lecture notes, but slides will be made available on the course webpage.

Course material Script, computer demonstrations, exercises and problem solutions available.

Deep Learning


J. M. Buhmann

Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:

  Advanced Machine Learning
  https://ml2.inf.ethz.ch/courses/aml/

  Computational Intelligence Lab
  http://da.inf.ethz.ch/teaching/2019/CIL/

  Introduction to Machine Learning
  https://las.inf.ethz.ch/teaching/introml-S19

  Statistical Learning Theory
  http://ml2.inf.ethz.ch/courses/slt/

  Computational Statistics
  https://stat.ethz.ch/lectures/ss19/comp-stats.php

  Probabilistic Artificial Intelligence
  https://las.inf.ethz.ch/teaching/pai-f18

151-0563-01L Dynamic Programming and Optimal Control W 4 credits 2V+1U R. D’Andrea

Abstract
Introduction to Dynamic Programming and Optimal Control.

Objective
Covers the fundamental concepts of Dynamic Programming & Optimal Control.

Content
Dynamic Programming Algorithm; Deterministic Systems and Shortest Path Problems; Infinite Horizon Problems, Bellman Equation; Deterministic Continuous-Time Optimal Control.

Literature

Prerequisites / notice
Requirements: Knowledge of advanced calculus, introductory probability theory, and matrix-vector algebra.

151-0851-00L Robot Dynamics W 4 credits 2V+2U M. Hutter, R. Siegwart

Abstract
We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

Objective
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

Content
The course consists of three parts: First, we will refresh and deepen the student’s knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aeronautics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

Prerequisites / notice
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

401-5860-00L Seminar in Robotics for CSE W 4 credits 2S M. Hutter, R. Katzschmann, E. Konukoglu, B. Nelson, R. Siegwart, M. Zeilinger

Abstract
This course provides an opportunity to familiarize yourself with the advanced topics of robotics and mechatronics research. The study plan has to be discussed with the lecturer based on your specific interests and/or the relevant seminar series such as the IRIS’s Robotics Seminars and BIRONZ lectures, for example.

Objective
The students are familiar with the challenges of the fascinating and interdisciplinary field of Robotics and Mechatronics. They are introduced in the basics of independent non-experimental scientific research and are able to summarize and to present the results efficiently.

Content
This 4 ECTS course requires each student to discuss a study plan with the lecturer and select minimum 10 relevant scientific publications to read through, or attend 5-10 lectures of the public robotics oriented seminars (e.g. Public robotics seminars such as the IRIS’s Robotics Seminars http://www.iris.ethz.ch/iris/series/, and BIRONZ lectures http://www.brl.ethz.ch/bronz/index are good examples). At the end of the semester, the results should be presented in an oral presentation and summarized in a report, which takes the discussion of the presentation into account.

Robots (continued)

Only one of the two course units
263-5902-00L Computer Vision resp. 227-0447-00L Image Analysis and Computer Vision may be recognised for credits. More precisely, it is also not allowed to have recognised one course unit for the Bachelor's and the other course unit for the Master's degree.

The same restriction applied to the two course units 263-5210-00L Probabilistic Artificial Intelligence resp. 227-0447-00L Image Analysis and Computer Vision.

252-0535-00L Advanced Machine Learning

For the category assignment take contact with the Study Administration (www.math.ethz.ch/studiensekretariat).

Number Title Type ECTS Hours Lecturers
263-5902-00L Computer Vision W 8 credits 3V+1U+3A M. Pollefeys, S. Tang, F. Yu

The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.
Quantum Mechanics I

Lecture notes and slides are available online and will be distributed if desired. The material covered in the course "Introduction to Machine Learning" is considered as a prerequisite.

For the field of specialization 'Physics' basic knowledge in quantum mechanics is required.

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>402-0809-00L</td>
<td>Introduction to Computational Physics</td>
<td>W</td>
<td>8</td>
<td>2V+2U</td>
<td>A. Adelmann</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>This course offers an introduction to computer simulation methods for physics problems and their implementation on PCs and super computers. The covered topics include classical equations of motion, partial differential equations (wave equation, diffusion equation, Maxwell's equations), Monte Carlo simulations, percolation, phase transitions, and N-Body problems.</td>
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<td>Students learn to apply the following methods: Random number generators, Determination of percolation critical exponents, numerical solution of problems from classical mechanics and electrodynamics, canonical Monte-Carlo simulations to numerically analyze magnetic spin systems.</td>
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<td></td>
<td>Introduction to computer simulation methods for physics problems. Models from classical mechanics, electrodynamics and statistical mechanics as well as some interdisciplinary applications are used to introduce modern programming methods for numerical simulations using Julia. Furthermore, an overview of existing software libraries for numerical simulations is presented.</td>
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<td>Literature recommendations and references are included in the lecture notes.</td>
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<tr>
<td>402-0205-00L</td>
<td>Quantum Mechanics I</td>
<td>W</td>
<td>10</td>
<td>3V+2U</td>
<td>C. Anastasiou</td>
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<td>Abstract</td>
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<td>Introduction to single-particle quantum mechanics. Familiarity with basic ideas and concepts (quantisation, operator formalism, symmetries, angular momentum, perturbation theory) and generic examples and applications (bound states, tunneling, hydrogen atom, harmonic oscillator). Ability to solve simple problems.</td>
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<td>The beginnings of quantum theory with Planck, Einstein and Bohr; Wave mechanics; Simple examples; The formalism of quantum mechanics (states and observables, Hilbert spaces and operators, the measurement process); Heisenberg uncertainty relation; Harmonic oscillator; Symmetries (in particular rotations); Hydrogen atom; Angular momentum addition; Quantum mechanics and classical physics (EPR paradox and Bell's inequality); Perturbation theory.</td>
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<td></td>
<td>G. Baym, Lectures on Quantum Mechanics</td>
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<td>E. Merzbacher, Quantum Mechanics</td>
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<td>L.I. Schiff, Quantum Mechanics</td>
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<td></td>
<td>R. Feynman and A.R. Hibbs, Quantum Mechanics and Path Integrals</td>
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<td>J.J. Sakurai: Modern Quantum Mechanics</td>
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<td>A. Messiah: Quantum Mechanics I</td>
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<td>S. Weinberg: Lectures on Quantum Mechanics</td>
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Distributed via moodle.

Communication

Topics to be covered include

Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

Lecturers

J. Renes

A. Adelmann

First introduction to main modelling ideas and mathematical tools from mathematical finance.

This course mainly aims at non-mathematicians who need an introduction to the main tools from stochastic calculus, Brownian motion, and probabilistic analysis used in mathematical finance. However, the course will also be of interest to mathematicians who work in related fields and need a basic introduction to mathematical finance.

Prerequisites

Mathematical Foundations for Finance

Lecturers

A. Adelmann

J. Renes

A. Adelmann

402-0461-00L Quantum Information Theory

Abstract

The goal of this course is to introduce the concepts and methods of quantum information theory. It starts with an introduction to the mathematical theory of quantum systems and then discusses the basic information-theoretic aspects of quantum mechanics. Further topics include applications such as quantum cryptography and quantum coding theory.

Objective

By the end of the course students are able to explain the basic mathematical formalism (e.g. states, channels) and the tools (e.g. entropy, distinguishability) of quantum information theory. They are able to adapt and apply these concepts and methods to analytically solve quantum information-processing problems primarily related to communication and cryptography.

Content

Mathematical formulation of quantum theory: entanglement, density operators, quantum channels and their representations. Basic tools of quantum information theory: distinguishability of states and channels, formulation as semidefinite programs, entropy and its properties. Applications of the concepts and tools: communication of classical or quantum information over noisy channels, quantitative uncertainty relations, randomness generation, entanglement distillation, security of quantum cryptography.

Lecture notes

Distributed via moodle.

Literature

Nielsen and Chuang, Quantum Information and Computation

Preskill, Lecture Notes on Quantum Computation

Wild, Quantum Information Theory

Watrous, The Theory of Quantum Information

402-0777-00L Particle Accelerator Physics and Modeling I

Abstract

This is the first of two courses, introducing particle accelerators from a theoretical point of view and covers state-of-the-art modelling techniques.

Objective

You understand the building blocks of particle accelerators. Modern analysis tools allows you to model state-of-the-art particle accelerators. In some of the exercises you will be confronted with next generation machines. We will develop a Python (or Julia) simulation tool (pyAcceLEGOrator or jAcceLEGOrator) that reflects the theory from the lecture.

Content

Here is the rough plan of the topics, however the actual pace may vary relative to this plan.

- Recap of Relativistic Classical Mechanics and Electrodynamics
- Building Blocks of Particle Accelerators
- Lie Algebraic Structure of Classical Mechanics and Application to Particle Accelerators
- Symplectic Maps & Analysis of Maps
- Symplectic Particle Tracking
- Collective Effects
- Linear & Circular Accelerators

Lecture notes

Lecture notes

Prerequisites / notice

Physics, Computational Science (RW) at BSc. Level

This lecture is also suited for PhD. students

401-5810-00L Seminar in Physics for CSE

Abstract

In this seminar, the students present a talk on an advanced topic in modern theoretical or computational physics. An implementation of an advanced algorithm can also be presented.

Objective

To teach students the topics of current interest in computational and theoretical physics.

Computational Finance

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
401-3913-01L | Mathematical Foundations for Finance | W | 4 | 3+2U | M. Schweizer

Abstract

First introduction to main modelling ideas and mathematical tools from mathematical finance

Objective

This course gives a first introduction to the main modelling ideas and mathematical tools from mathematical finance. It mainly aims at non-mathematicians who need an introduction to the main tools from stochastic processes used in mathematical finance. However, mathematicians who want to learn some basic modelling ideas and concepts for quantitative finance (before continuing with a more advanced course) may also find this of interest.

Content

Topics to be covered include

- financial market models in finite discrete time
- absence of arbitrage and martingale measures
- valuation and hedging in complete markets
- basics about Brownian motion
- stochastic integration
- stochastic calculus: Itô’s formula, Girsanov transformation, Itô’s representation theorem
- Black-Scholes formula

Lecture notes

See information on course homepage

Data: 01.11.2022 12:41

Autumn Semester 2022

Page 2029 of 2416
Prerequisites / notice
Prerequisites: Results and facts from probability theory as in the book "Probability Essentials" by J. Jacod and P. Protter will be used freely. Especially participants without a direct mathematics background are strongly advised to familiarise themselves with those tools before (or very quickly during) the course. (A possible alternative to the above English textbook are the (German) lecture notes for the standard course "Wahrscheinlichkeitslehre".) For those who are not sure about their background, we suggest to look at the exercises in Chapters 8, 9, 22-25, 28 of the Jacod/Protter book. If these pose problems, you will have a hard time during the course. So be prepared.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed
Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
Personal Competencies
- Problem-solving: assessed
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: not assessed
- Integrity and Work Ethics: not assessed

401-4657-00L Numerical Solution of Stochastic Ordinary Differential Equations

Abstract
This course is on the numerical approximations of stochastic ordinary differential equations (SDEs) driven by Brownian motions and Lévy processes. SDEs have several applications, for example in financial engineering. The contents cover stochastic processes, stochastic calculus, well-posedness results for SDEs, strong and weak approximations of SDEs, and simulation via Monte Carlo methods.

Objective
The aim of this course is to enable the students to carry out simulations and their mathematical convergence analysis for stochastic models originating from applications such as mathematical finance. For this the course teaches a decent knowledge of the different numerical methods, their underlying ideas, convergence properties and implementation issues.

Content
- Brownian motion and Lévy processes
- Stochastic integration and stochastic calculus
- Stochastic ordinary differential equations (SDEs)
- Numerical approximations of SDEs
- Stochastic simulation and Monte Carlo methods
- Applications to computational finance: Option valuation

Lecture notes
There will be English, typed lecture notes for registered participants in the course.

Literature

Prerequisites / notice
Prerequisites:
Mandatory: Probability and measure theory, basic numerical analysis and basics of MATLAB/Python programming.
a) mandatory courses: Elementary Probability, Probability Theory I.
b) recommended courses: Stochastic Processes.

Start of lectures: Wednesday September 21, 2022.

401-8905-00L Financial Engineering (University of Zurich)

Abstract
This lecture is intended for students who would like to learn more on equity derivatives modelling and pricing.

Objective
Quantitative models for European option pricing (including stochastic volatility and jump models), volatility and variance derivatives, American and exotic options.
After introducing fundamental concepts of mathematical finance including no-arbitrage, portfolio replication and risk-neutral measure, we will present the main models that can be used for pricing and hedging European options e.g. Black-Scholes model, stochastic and jump-diffusion models, and highlight their assumptions and limitations. We will cover several types of derivatives such as European and American options, Barrier options and Variance-Swaps. Basic knowledge in probability theory and stochastic calculus is required. Besides attending class, we strongly encourage students to stay informed on financial matters, especially by reading daily financial newspapers such as the Financial Times or the Wall Street Journal.

Lecture notes

Prerequisites / notice

Basic knowledge of probability theory and stochastic calculus.

Asset Pricing.

363-0561-00L Financial Market Risks

| W | 3 credits | 2G | not available |

Abstract

I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

Objective

The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

- Development of the concepts and tools to understand these risks and master them.
- Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)
- Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks

Content

1- The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of the perpetual money machine.

2- Risks in financial markets
   - What is risk?
   - Measuring risks of financial assets
   - Introduction to three different concepts of probability
   - History of financial markets, diversification, market risks

3- Introduction to financial risks and its management.
   - Relationship between risk and return
   - Portfolio theory: the concept of diversification and optimal allocation
   - How to price assets: the Capital Asset Pricing Model
   - How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4- Financial markets: role and efficiency
   - What is an efficient market?
   - Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
   - Deviations from efficiency, puzzles and anomalies in the financial markets
   - Financial bubbles, crashes, systemic instabilities

5- An introduction to Options and derivatives
   - Calls, Puts and Shares and other derivatives
   - Financial alchemy with options (options are building blocks of any possible cash flow)
   - Determination of option value; concept of risk hedging

6- Valuation and using options
   - A first simple option valuation model
   - The Binomial method for valuing options
   - The Black-scholes model and formula
   - Practical examples and implementation
   - Realized prices deviate from these theories: volatility smile and real option trading
   - How to imperfectly hedge with real markets?

7- Real options
   - The value of follow-on investment opportunities
   - The timing option
   - The abandonment option
   - Flexible production
   - Conceptual aspects and extensions

8- Government bonds and their valuation
   - Relationship between bonds and interest rates
   - Real and nominal rates of interest
   - Term structure and yields to maturity
   - Explaining the term structure
   - Different models of the term structure

9- Managing international risks
   - The foreign exchange market
   - Relations between exchanges rates and interest rates, inflation, and other economic variables
   - Hedging currency risks
   - Currency speculation
   - Exchange risk and international investment decisions

Lecture notes

Lecture slides will be available on the site of the lecture
You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions.

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After

W. U. Koch

The lecture covers the following topics:

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is

Lecture notes and slides will be handed out during the lectures.

J. Smajic

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main

Hours

This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and


Prerequisites / notice

None

401-5820-00L Seminar in Computational Finance for CSE W 4 credits 2S J. Teichmann

Content

We aim to comprehend recent and exciting research on the nature of stochastic volatility: an extensive econometric research [4] lead to new insights on stochastic volatility, in particular that very rough fractional processes of Hurst index about 0.1 actually provide very attractive models. Also from the point of view of pricing [1] and microfoundations [2] these models are very convincing.

More precisely each student is expected to work on one specified task consisting of a theoretical part and an implementation with financial data, whose results should be presented in a 45 minutes presentation.

Literature


Prerequisites / notice

Requirements: sound understanding of stochastic concepts and of concepts of mathematical Finance, ability to implement econometric or simulation routines in MATLAB.

Electromagnetics

Number

Title

Type

ECTS

Hours

Lecturers

227-0110-00L Electromagnetic Waves: Materials, Effects, and Antennas

W

6 credits

4G

U. Koch

Abstract

This course provides profound knowledge of electromagnetic waves. Various types of materials, nonlinear and resonant effects, and antenna applications are discussed.

Objective

You can describe wave propagation in classical and nonclassical materials and know the fundamental solutions.

You know how waves interact with matter and about nonlinear and resonant effects.

You can apply the acquired knowledge in scattering, waveguiding, radiation, and antenna problems.

Content

The lecture covers the following topics:

• Generic time-harmonic electromagnetic fields
• Fundamental solutions of the wave equation
• Wave propagation in various types of materials
• Interaction of waves with matter
• Nonlinear effects
• Resonant effects
• Applications like scattering, waveguiding, radiation
• Radio frequency and optical antennas

Lecture notes

Lecture notes and slides will be handed out during the lectures.

Prerequisites / notice

Remark: the lecture succeeds «Advanced Electromagnetic Waves» and reorientates itself to materials, effects, and applications with waves.

227-2037-00L Physical Modelling and Simulation

W

6 credits

4G

J. Smajic

Abstract

This module consists of (a) an introduction to fundamental equations of electromagnetics, mechanics and heat transfer, (b) a detailed overview of numerical methods for field simulations, and (c) practical examples solved in form of small projects.

Objective

Basic knowledge of the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. Knowledge of the main concepts of numerical methods for physical modelling and simulation. Ability (a) to develop own simple field simulation programs, (b) to select an appropriate field solver for a given problem, (c) to perform field simulations, (d) to evaluate the obtained results, and (e) to interactively improve the models until sufficiently accurate results are obtained.

Content

The module begins with an introduction to the fundamental equations and effects of electromagnetics, mechanics, and heat transfer. After the introduction follows a detailed overview of the available numerical methods for solving electromagnetic, thermal and mechanical boundary value problems. This part of the course contains a general introduction into numerical methods, differential and integral forms, linear equation systems, Finite Difference Method (FDM), Boundary Element Method (BEM), Method of Moments (MoM), Multiple Multipole Program (MMP) and Finite Element Method (FEM). The theoretical part of the course finishes with a presentation of multiphysics simulations through several practical examples of HF-engineering such as coupled electromagnetic-mechanical and electromagnetic-thermal analysis of MEMS.

In the second part of the course the students will work in small groups on practical simulation problems. For solving practical problems the students can develop and use own simulation programs or chose an appropriate commercial field solver for their specific problem. This practical simulation work of the students is supervised by the lecturers.

227-0301-00L Optical Communication Fundamentals

W

6 credits

2V+1U+1P

J. Leuthold

Abstract

The path of an analog signal in the transmitter to the digital world in a communication link and back to the analog world at the receiver is discussed. The lecture covers the fundamentals of all important optical and optoelectronic components in a fiber communication system. This includes the transmitter, the fiber channel and the receiver with the electronic digital signal processing elements.

Objective

An in-depth understanding on how information is transmitted from source to destination. Also the mathematical framework to describe the important elements will be passed on. Students attending the lecture will further get engaged in critical discussion on societal, economical and environmental aspects related to the on-going exponential growth in the field of communications.
In this course, students learn crucial partial differential equations (conservation laws) that are applicable to any continuum including the Earth's mantle, core, atmosphere and ocean. The course will provide step-by-step introduction into the mathematical structure, physical meaning and analytical solutions of the equations. The course has a particular focus on solid Earth applications.

The aim of this course is to review new and fundamental mathematical tools, computational approaches, and inversion and optimal design methods used to address challenging problems in nanophotonics. The emphasis will be on analyzing plasmon resonant nanoparticles, super-focusing & super-resolution of electromagnetic waves, photonic crystals, electromagnetic cloaking, metamaterials, and metasurfaces as modern topics such as photonic crystals, metamaterials, plasmonics, etc. are considered.

The field of photonics encompasses the fundamental science of light propagation and interactions in complex structures, and its applications from statics to optics. Traditional problems such as antennas, electromagnetic scattering, waveguides, resonators, etc. as well as modern topics such as photonic crystals, metamaterials, plasmonics, etc. are considered.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonic crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-mathematics in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena.

An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare.

The recent advances in nanoscience present great challenges for the applied and computational mathematics community. In nanophotonics, the aim is to control, manipulate, reshape, guide, and focus electromagnetic waves at nanometer length scales, beyond the resolution limit. In particular, one wants to break the resolution limit by reducing the focal spot and confine light to length scales that are significantly smaller than half the wavelength.

The main objective in this course is to report on the use of sophisticated mathematics in diffractive optics, plasmonics, super-resolution, photonic crystals, and metamaterials for electromagnetic invisibility and cloaking. The book merges highly nontrivial multi-mathematics in order to make a breakthrough in the field of mathematical modelling, imaging, and optimal design of optical nanodevices and nanostructures capable of light enhancement, and of the focusing and guiding of light at a subwavelength scale. We demonstrate the power of layer potential techniques in solving challenging problems in photonics, when they are combined with asymptotic analysis and the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions.

In this course we shall consider both analytical and computational matters in photonics. The issues we consider lead to the investigation of fundamental problems in various branches of mathematics. These include asymptotic analysis, spectral analysis, mathematical imaging, optimal design, stochastic modelling, and analysis of wave propagation phenomena. On the other hand, deriving mathematical foundations, and new and efficient computational frameworks and tools in photonics, requires a deep understanding of the different scales in the wave propagation problem, an accurate mathematical modelling of the nanodevices, and fine analysis of complex wave propagation phenomena.

An emphasis is put on mathematically analyzing plasmon resonant nanoparticles, diffractive optics, photonic crystals, super-resolution, and metamaterials.

Interactions between the field of photonics and mathematics has led to the emergence of a multitude of new and unique solutions in which today's conventional technologies are approaching their limits in terms of speed, capacity and accuracy. Light can be used for detection and measurement in a fast, sensitive and accurate manner, and thus photonics possesses a unique potential to revolutionize healthcare.

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A provisional week-by-week schedule (subject to change) is as follows:

Weeks 1,2: The continuity equation

Weeks 3,4: Density and gravity

Weeks 5,6: Stress and strain

Weeks 7,8: The momentum equation

Week 9: Viscous rheology of rocks
Theory: Solid-state creep of minerals and rocks as the major mechanism of deformation of the Earth's interior. Dislocation and diffusion creep mechanisms. Rheological equations for minerals and rocks. Effective viscosity and its dependence on temperature, pressure and strain rate. Formulation of the effective viscosity from empirical flow laws. Exercise: Deriving viscous rheological equations for computing effective viscosities from empirical flow laws.

Weeks 10,11: The heat conservation equation

Week 12,13: Elasticity and plasticity


GRADING will be based on homeworks (1/3) and oral exam (2/3).

Lecture notes
Script and Exam questions are available by request tgerya@ethz.ch

Literature

Geophysics: Subject 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>651-4241-00L</td>
<td>Numerical Modelling I and II: Theory and Applications</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>T. Gerya</td>
</tr>
</tbody>
</table>

Abstract

In this 13-week sequence, students learn how to write programs from scratch to solve partial differential equations that are useful for Earth science applications. Programming will be done in MATLAB and will use the finite-difference method and marker-in-cell technique. The course will emphasize a hands-on learning approach rather than extensive theory.

Objective

The goal of this course is for students to learn how to program numerical applications from scratch. By the end of the course, students should be able to write state-of-the-art MATLAB codes that solve systems of partial-differential equations relevant to Earth and Planetary Science applications using finite-difference method and marker-in-cell technique. Applications include Poisson equation, buoyancy driven variable viscosity flow, heat diffusion and advection, and state-of-the-art thermomechanical code programming. The emphasis will be on commonality, i.e., using a similar approach to solve different applications, and modularity, i.e., re-use of code in different programs. The course will emphasize a hands-on learning approach rather than extensive theory, and will begin with an introduction to programming in MATLAB.
A provisional week-by-week schedule (subject to change) is as follows:

Week 1: Introduction to the finite difference approximation to differential equations. Introduction to programming in Matlab. Solving of 1D Poisson equation.


Week 3: Solving momentum and continuity equations in case of constant viscosity using stream function/vorticity formulation.


Weeks 5: Conservative finite differences for the momentum equation. "Free slip" and "no slip" boundary conditions. Solving momentum and continuity equations in case of variable viscosity using pressure-velocity formulation with staggered grid.


Week 7: Advection in 2-D with Marker-in-cell method. Combining flow calculation and advection for buoyancy driven flow.


Week 9: Solving 2D heat conservation equation in case of constant thermal conductivity with explicit and implicit approaches.

Week 10: Solving 2D heat conservation equation in case of variable thermal conductivity with implicit approach. Temperature advection with markers. Creating thermomechanical code by combining mechanical solution for 2D buoyancy driven flow with heat diffusion and advection based on marker-in-cell approach.

Week 11: Implementation of radioactive, adiabatic and shear heating to the thermomechanical code.

Week 12: Programming of solution of coupled solid-fluid momentum and continuity equations for the case of melt percolation in a rising mantle plume.


Final project description for slab breakoff modeling.

GRADING will be based on weekly programming homeworks (50%) and a term project (50%) to develop an application of their choice to a more advanced level.

Literature
### Geophysics: Seminar

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-5880-00L</td>
<td>Seminar in Geophysics for CSE</td>
<td>W</td>
<td>6 credits</td>
<td>2S</td>
<td>T. Gerya, P. Tackley</td>
</tr>
</tbody>
</table>

**Abstract**
The seminar in geophysics for CSE is a work on a small research project for 4 credit points. The project can be supervised and graded by any member of the Institute of Geophysics with doctoral degree.

**Objective**
Students should find a project of interest by contacting potential supervisors from the Institute of Geophysics and agree on the content and timing of the project. At the end of the project, a written report of free format should be submitted by the student, which is then graded by the supervisor.

**Lecture notes**
No script

**Literature**
Relevant literature should be provided by the project supervisor.

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, not assessed

### Biology

<table>
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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>636-0007-00L</td>
<td>Computational Systems Biology</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2U</td>
<td>J. Stelling</td>
</tr>
</tbody>
</table>

**Abstract**
Study of fundamental concepts, models and computational methods for the analysis of complex biological networks. Topics: Systems approaches in biology, biology and reaction network fundamentals, modelling and simulation approaches (topological, probabilistic, stoichiometric, qualitative, linear / nonlinear ODEs, stochastic), and systems analysis (complexity reduction, stability, identification).

**Objective**
The aim of this course is to provide an introductory overview of mathematical and computational methods for the modeling, simulation and analysis of biological networks.

**Content**
- Biology has witnessed an unprecedented increase in experimental data and, correspondingly, an increased need for computational methods to analyze this data. The explosion of sequenced genomes, and subsequently, of bioinformatics methods for the storage, analysis and comparison of genetic sequences provides a prominent example. Recently, however, an additional area of research, captured by the label “Systems Biology”, focuses on how networks, which are more than the mere sum of their parts' properties, establish biological functions. This is essentially a task of reverse engineering. The aim of this course is to provide an introductory overview of corresponding computational methods for the modeling, simulation and analysis of biological networks.
- We will start with an introduction into the basic units, functions and design principles that are relevant for biology at the level of individual cells. Making extensive use of example systems, the course will then focus on methods and algorithms that allow for the investigation of biological networks with increasing detail. These include (i) graph theoretical approaches for revealing large-scale network organization, (ii) probabilistic (Bayesian) network representations, (iii) structural network analysis based on reaction stoichiometries, (iv) qualitative methods for dynamic modeling and simulation (Boolean and piece-wise linear approaches), (v) mechanistic modeling using ordinary differential equations (ODEs) and finally (vi) stochastic simulation methods.

**Lecture notes**
http://www.csb.ethz.ch/education/lectures.html

**Literature**

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>636-0017-00L</td>
<td>Computational Biology</td>
<td>W</td>
<td>6 credits</td>
<td>3V+2A</td>
<td>T. Vaughan, C. Magnus, T. Stadler</td>
</tr>
</tbody>
</table>

**Abstract**
The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.
Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:
- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:
- epidemiology
- pathogen evolution
- macroevolution of species

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylodynamics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the class, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

Lecture notes: Lecture slides will be available on moodle.

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

- * pathogen evolution

- * macroevolution of species

- * stochastic models in molecular evolution

- * phylogenetic & phylodynamic inference

- * maximum likelihood and Bayesian statistics

- * epidemiology

- * pathogen evolution

- * macroevolution of species

- * stochastic models in molecular evolution

- * phylogenetic & phylodynamic inference

- * maximum likelihood and Bayesian statistics

- * epidemiology

- * pathogen evolution

- * macroevolution of species

Lectures notes: Lecture slides will be available on moodle.

The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

1. Introduction to Modelling in Biology
2. Bioimage Analysis
3. Morphogen Gradients
4. Precision & Robustness of Patterning
5. Mathematical Description of Growing Biological Systems
6. Travelling Waves & Wave Pinning
7. Turing Patterns
8. Chemotaxis
9. Epithelial Organisation
10. Tissue Simulation Frameworks
11. Tissue Mechanics & Fluid Dynamics
12. Growth Control
13. Image-Based Modelling
14. Summary

Prerequisites / notice: The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

636-0706-00L Spatio-Temporal Modelling in Biology W 4 credits 3G D. Iber

Abstract: This course focuses on modeling spatio-temporal problems in biology, in particular on the cell and tissue level. The main focus is on mechanisms and concepts, but mathematical and numerical techniques are introduced as required. Biological examples discussed in the course provide an introduction to key concepts in developmental biology.

Objective: Students will learn state-of-the-art approaches to modelling spatial effects in dynamical biological systems. The course provides an introduction to dynamical system, and covers the mathematical analysis of pattern formation in growing, developing systems, as well as the description of mechanical effects at the cell and tissue level. The course also provides an introduction to image-based modelling, i.e. the use of microscopy data for model development and testing. The course covers classical as well as current approaches and exposes students to open problems in the field. In this way, the course seeks to prepare students to conduct research in the field. The course prepares students for research in developmental biology, as well as for applications in tissue engineering, and for biomedical research.

Lecture notes: All lecture material will be made available online via Moodle.

Literature:
- Murray, Mathematical Biology, Springer
- Forgacs and Newman, Biological Physics of the Developing Embryo, CUP
- Keener and Sneyd, Mathematical Physiology, Springer
- Fall et al. Computational Cell Biology, Springer
- Szalasi et al, System Modeling in Cellular Biology, MIT Press
- Wolkenhauer, Systems Biology
- Keijzer, Engineering Mathematics, Wiley

Prerequisites / notice: The course is self-contained. The course assumes no background in biology but a good foundation regarding mathematical and computational techniques.

227-0421-00L Deep Learning in Artificial and Biological Neuronal Networks W 4 credits 3G B. Grewe

Abstract: Deep-Learning (DL) a brain-inspired weak for of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. However, DL is far from being understood and investigating learning in biological networks might serve again as a compelling inspiration to think differently about state-of-the-art ANN training methods.

Objective: The main goal of this lecture is to provide a comprehensive overview into the learning principles neuronal networks as well as to introduce a diverse skill set (e.g. simulating a spiking neuronal network) that is required to understand learning in large, hierarchical neuronal networks. To achieve this the lectures and exercises will merge ideas, concepts and methods from machine learning and neuroscience. These will include training basic ANNs, simulating spiking neuronal networks as well as being able to read and understand the main ideas presented in today’s neuroscience papers.

After this course students will be able to:
- read and understand the main ideas and methods that are presented in today's neuroscience papers
- explain the basic ideas and concepts of plasticity in the mammalian brain
- implement alternative ANN learning algorithms to 'error backpropagation' in order to train deep neuronal networks.
- use a diverse set of ANN regularization methods to improve learning
- simulate spiking neuronal networks that learn simple (e.g. digit classification) tasks in a supervised manner.
Deep-learning a brain-inspired weak form of AI allows training of large artificial neuronal networks (ANNs) that, like humans, can learn real-world tasks such as recognizing objects in images. The origins of deep hierarchical learning can be traced back to early neuroscience research by Hubel and Wiesel in the 1960s, who first described the neuronal processing of visual inputs in the mammalian neocortex. Similar to their neocortical counterparts ANNs seem to learn by interpreting and structuring the data provided by the external world. However, while on specific tasks such as playing (video) games deep ANNs outperform humans (Minh et al., 2015; Silver et al., 2018). ANNs are still not performing on par when it comes to recognizing actions in movie data and their ability to act as generalizable problem solvers is still far behind what the human brain seems to achieve effortlessly. Moreover, biological neuronal networks can learn far more effectively with fewer training examples, they achieve a much higher performance in recognizing complex patterns in time series data (e.g. recognizing actions in movies), they dynamically adapt to new tasks without losing performance and they achieve unmatched performance to detect and integrate out-of-domain data examples (data they have not been trained with). In other words, many of the big challenges and unknowns that have emerged in the field of deep learning over the last years are already mastered exceptionally well by biological neuronal networks in our brain. On the other hand, many facets of typical ANN design and training algorithms seem biologically implausible, such as the non-local weight updates, discrete processing of time, and scalar communication between neurons. Recent evidence suggests that learning in biological systems is the result of the complex interplay of diverse error feedback signaling processes acting at multiple scales, ranging from single synapses to entire networks.

### Electives

In the ‘electives’ subcategory, at least two course units must be successfully completed.

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<tr>
<th>Number</th>
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<th>Lecturers</th>
</tr>
</thead>
</table>
Abstract
This course aims to cover state-of-the-art methods in modern parallel Graphical Processing Unit (GPU) computing, supercomputing and code development with applications to natural sciences and engineering.

Objective
When quantitative assessment of physical processes governing natural and engineered systems relies on numerically solving differential equations, fast and accurate solutions require performant algorithms leveraging parallel hardware. The goal of this course is to offer a practical approach to solve systems of differential equations in parallel on GPUs using the Julia language. Julia combines high-level language conciseness to low-level language performance which enables efficient code development.

The course will be taught in a hands-on fashion, putting emphasis on you writing code and completing exercises; lecturing will be kept at a minimum. In a final project you will solve a solid mechanics or fluid dynamics problem of your interest, such as the shallow water equation, the shallow ice equation, acoustic wave propagation, nonlinear diffusion, viscous flow, elastic deformation, viscous or elastic poromechanics, frictional heating, and more. Your Julia GPU application will be hosted on a git-platform and implement modern software development practices.

Content
Part 1 - Discovering a modern parallel computing ecosystem
- Learn the basics of the Julia language;
- Learn about the diffusion process and how to solve it;
- Understand the practical challenges of parallel and distributed computing: (multi-)GPUs, multi-core CPUs;
- Learn about software development tools: git, version control, continuous integration (CI), unit tests.

Part 2 - Developing your own parallel algorithms
- Implement wave propagation and porous convection;
- Apply spatial and temporal discretisation (finite-differences, various time-stepper);
- Implement efficient iterative algorithms;
- Implement shared (on CPU and GPU) and distributed memory parallelisation (multi-GPUs/CUDA);
- Learn about main simulation performance limiters.

Part 3 - Final project
- Apply your new skills in a final project;
- Implement advanced physical processes (solid and fluid dynamic - elastic and viscous solutions).

Lecture notes
Digital lecture notes, interactive Julia notebooks, online material.

Literature
Links to relevant literature will be provided during classes.

Prerequisites / notice
Completed BSc studies. Interest in and basic knowledge of numerics, applied mathematics, and physics/engineering sciences. Basic programming skills (in e.g. Matlab, Python, Julia); advanced programming skills are a plus.

151-0317-00L Visualization, Simulation and Interaction - Virtual Reality II

4 credits
3G
A. Kunz

Abstract
This lecture provides deeper knowledge on the possible applications of virtual reality, its basic technolgy, and future research fields. The goal is to provide a strong knowledge on Virtual Reality for a possible future use in business processes.

Objective
Virtual Reality can not only be used for the visualization of 3D objects, but also offers a wide application field for small and medium enterprises (SME). This could be for instance an enabling technology for net-based collaboration, the transmission of images and other data, the interaction of the human user with the digital environment, or the use of augmented reality systems.

The goal of the lecture is to provide a deeper knowledge of today's VR environments that are used in business processes. The technical background, the algorithms, and the applied methods explained are more in detail. Finally, future tasks of VR will be discussed and an outlook on ongoing international research is given.

Content
Introduction into Virtual Reality; basics of augmented reality; interaction with digital data, tangible user interfaces (TUI); basics of simulation; compression procedures of image-, audio-, and video signals; new materials for force feedback devices; introduction into data security; cryptography; definition of free-form surfaces; digital factory; new research fields of virtual reality

Lecture notes
The handout is available in German and English.

Prerequisites
"Visualization, Simulation and Interaction - Virtual Reality I" is recommended, but not mandatory.

Didactical concept:
The course consists of lectures and exercises.

Fostered competencies
Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Media and Digital Technologies

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Creative Thinking
Critical Thinking

151-0317-00L Advanced Model Predictive Control

4 credits
2V+1U
M. Zeilinger, A. Carron, L. Hewing, J. Köhler

Abstract
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of recent advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

Objective
Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

Content
Topics include
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

Lecture notes
Lecture notes will be provided.

Prerequisites
Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended.
Background in linear algebra and stochastic systems recommended.

151-0833-00L Applied Finite Element Analysis

4 credits
2V+2U
B. Berisha, D. Mohr

Abstract
This course provides an introduction to the application of finite element models in the analysis of partial differential equations, used in a variety of fields such as structural mechanics, fluid dynamics, heat transfer, and electromagnetics.

Objective
The course aims to teach the fundamentals of the finite element method, including the formulation of variational problems, the generation of finite element models, and the implementation of computer codes.

Content
- Introduction to the finite element method
- Linear and non-linear elasticity
- Fluid mechanics
- Heat transfer
- Electromagnetics
Most problems in engineering are of nonlinear nature. The nonlinearities are caused basically due to the nonlinear material behavior, contact conditions and instability of structures. The principles of the nonlinear Finite-Element-Method (FEM) will be introduced for treating such problems. The finite element program ABAQUS is introduced to investigate real engineering problems.

The goal of the lecture is to provide the students with the fundamentals of the non linear Finite Element Method (FEM). The lecture focuses on the principles of the nonlinear Finite-Element-Method based on explicit and implicit formulations. Typical applications of the nonlinear Finite-Element-Methods are simulations of:

- Crash
- Collapse of structures
- Material behavior (metals and rubber)
- General forming processes

Special attention will be paid to the modeling of the non-linear material behavior, thermo-mechanical processes and processes with large plastic deformations. The ability to independently create a virtual model which describes the complex non linear systems will be acquired through accompanying exercises. These will include the Matlab programming of important model components such as constitutive equations. The FEM Program ABAQUS will be introduced to investigate real engineering problems.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Elective Credits</th>
<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>6 credits</td>
<td>3V+2U+3A</td>
<td>T. Hoefler, M. Püschel</td>
</tr>
<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>5 credits</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
</tr>
</tbody>
</table>

The course provides an introduction to non-linear finite element analysis. The treated sources of non-linearity are related to material properties (hyperelasticity, plasticity), kinematics (large deformations, instability problems) and boundary conditions (contact).

To be able to address all major sources of non-linearity in theory and numerics, and to apply this knowledge to the solution of relevant problems in solid mechanics.

<table>
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<th>Instructor</th>
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</thead>
<tbody>
<tr>
<td>151-0529-00L</td>
<td>Computational Mechanics II: Nonlinear FEA</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>L. De Lorenzis</td>
</tr>
<tr>
<td>263-2800-00L</td>
<td>Design of Parallel and High-Performance Computing</td>
<td>9 credits</td>
<td>3V+2U+3A</td>
<td>T. Hoefler, M. Püschel</td>
</tr>
</tbody>
</table>

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are possible to use, such as tablets and phones.
- Good programming skills (C# / C++ / Java etc.)
- Instability problems

- Solvers and convergence
- Modeling of tool contact and the influence of friction
- Elasticity, plasticity, hyperelasticity, plasticity.
- Non-linear boundary conditions: contact problems.

Lecture notes will be provided. However, students are encouraged to take their own notes.

Lecture notes:

<table>
<thead>
<tr>
<th>Lecture Slides</th>
<th>Book</th>
<th>Page</th>
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</thead>
</table>

- Instability problems
- Solvers and convergence
- Modeling of tool contact and the influence of friction
- Elasticity, plasticity, hyperelasticity, plasticity.
- Non-linear boundary conditions: contact problems.

This class is intended for the Computer Science Masters curriculum. Students must have basic knowledge in programming in C as well as computer science theory. Students should be familiar with the material covered in the ETH computer science first-year courses "Parallele Programmierung (parallel programming)" and "Algorithmen und Datenstrukturen (algorithm and data structures)" or equivalent courses.

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

Prerequisites / notice:

- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

After attending this course, students will:

1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

- Introduction to Mixed Reality / Augmented Reality / Virtual Reality

The main focus of this course is student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/3D research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites include:

- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.

After attending this course, students will:

1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction
2. Have a clear understanding on how to build mixed reality apps
3. Have a good overview of state-of-the-art Mixed Reality
4. Be able to critically analyze and assess current research in this area.

The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:

- Introduction to Mixed Reality / Augmented Reality / Virtual Reality

The main focus of this course is student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/3D research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.

Prerequisites include:

- Good programming skills (C# / C++ / Java etc.)
- Computer graphics/vision experience: Students should have taken, at a minimum, Visual Computing. Higher level courses are recommended, such as Introduction to Computer Graphics, 3D Vision, Computer Vision.
**Objective**

Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

**Content**

1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

**Literature**

Available

[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger
D. Hochbaum

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitsrechnung und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser.

227-0116-00L

<table>
<thead>
<tr>
<th>VLSI 1: HDL Based Design for FPGAs</th>
<th>W</th>
<th>6 credits</th>
<th>5G</th>
<th>F. K. Göürkaynak, L. Benini</th>
</tr>
</thead>
</table>

**Abstract**

This first course in a series that extends over three consecutive terms is concerned with tailoring algorithms and with devising high performance hardware architectures for their implementation as ASIC or with FPGAs. The focus is on front end design using HDLs and automatic synthesis for producing industrial-quality circuits.

**Objective**

Understand Very-Large-Scale Integrated Circuits (VLSI chips), Application-Specific Integrated Circuits (ASIC), and Field-Programmable Gate-Arrays (FPGA). Know their organization and be able to identify suitable application areas. Become fluent in front-end design from architectural conception to gate-level netlists. How to model digital circuits with SystemVerilog. How to ensure they behave as expected with the aid of simulation, testbenches, and assertions. How to take advantage of automatic synthesis tools to produce industrial-quality VLSI and FPGA circuits. Gain practical experience with the hardware description language SystemVerilog and with industrial Electronic Design Automation (EDA) tools.

**Content**

This course is concerned with system-level issues of VLSI design and FPGA implementations. Topics include:
- Overview on design methodologies and fabrication depths.
- Levels of abstraction for circuit modeling.
- Organization and configuration of commercial field-programmable components.
- FPGA design flows.
- Dedicated and general purpose architectures compared.
- How to obtain an architecture for a given processing algorithm.
- Meeting throughput, area, and power goals by way of architectural transformations.
- Hardware Description Languages (HDL) and the underlying concepts.
- SystemVerilog
- Register Transfer Level (RTL) synthesis and its limitations.
- Building blocks of digital VLSI circuits.
- Functional verification techniques and their limitations.
- Modular and largely reusable testbenches.
- Assertion-based verification.
- Synchronous versus asynchronous circuits.
- The case for synchronous circuits.
- Periodic events and the Anceau diagram.
- Case studies, ASICs compared to microprocessors, DSPs, and FPGAs.

During the exercises, students learn how to model FPGAs with SystemVerilog. They write testbenches for simulation purposes and synthesize gate-level netlists for FPGAs. Commercial EDA software by leading vendors is being used throughout.

**Lecture notes**

Textbook and all further documents in English.

**Literature**

### VLSI 3: Full-Custom Digital Circuit Design

**Abstract**

This third course in our VLSI series is concerned with full-custom digital integrated circuits. The goals include learning the design of digital circuits on the schematic, layout, gate, and register-transfer levels. The use of state-of-the-art CAD software (Cadence Virtuoso) in order to simulate, optimize, and characterize digital circuits is another important topic of this course.

**Objective**

- At the end of this course, you will
  - understand the design of the main building blocks of state-of-the-art digital integrated circuits
  - be able to design and optimize digital integrated circuits on the schematic, layout, and gate levels
  - be able to use standard industry software (Cadence Virtuoso) for drawing, simulating, and characterizing digital circuits
  - understand the performance trade-offs between delay, area, and power consumption

**Content**

The third VLSI course begins with the basics of metal-oxide-semiconductor (MOS) field-effect transistors (FETs) and moves up the stack towards logic gates and increasingly complex digital circuit structures. The topics of this course include:

- Nanometer MOSFETs
- Static and dynamic behavior of complementary MOS (CMOS) inverters
- CMOS gate design, sizing, and timing
- Full-custom standard-cell design
- Wire models and parasitics
- Latch and flip-flop circuits
- Gate-level timing analysis and optimization
- Static and dynamic power consumption; low-power techniques
- Alternative logic styles (dynamic logic, pass-transistor logic, etc.)
- Arithmetic and logic circuits
- Fixed-point and floating-point arithmetic
- Synchronous and asynchronous design principles
- Memory circuits (ROM, SRAM, and DRAM)
- In- and near-memory processing architectures
- Full-custom accelerator circuits for machine learning

The exercises are concerned with schematic entry, layout, and simulation of digital integrated circuits using a disciplined standard-cell-based approach with Cadence Virtuoso.

**Literature**

- N. H. E. Weste and D. M. Harris, CMOS VLSI Design: A Circuits and Systems Perspective (4th Ed.), Addison-Wesley

**Prerequisites / notice**

VLSI 3 can be taken in parallel with “VLSI 1: HDL-based design for FPGAs” and is designed to complement the topics of this course. Basic analog circuit knowledge is required.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Problem-solving</td>
</tr>
</tbody>
</table>

**Examination:**

In written form following the course semester (spring term). Problems are given in English, answers will be accepted in either English or German.

**Further details:**

https://lis.students.ee.ethz.ch/lectures/vlsi-i/

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### Information Theory I

**Abstract**

This course covers the basic concepts of information theory and of communication theory. Topics covered include the entropy rate of a source, mutual information, typical sequences, the asymptotic equi-partition property, Huffman coding, channel capacity, the channel coding theorem, the source-channel separation theorem, and feedback capacity.

**Objective**

- The fundamentals of Information Theory including Shannon's source coding and channel coding theorems

**Content**

The entropy rate of a source, Typical sequences, the asymptotic equi-partition property, the source coding theorem, Huffman coding, Arithmetic coding, channel capacity, the source-channel separation theorem, feedback capacity

**Literature**

- T.M. Cover and J. Thomas, Elements of Information Theory (second edition)

**Prerequisites / notice**

- 227-0147-10L
- 6 credits
- 4G
- A. Lapidoth

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### Embedded Systems

**Abstract**

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

**Objective**

Understanding specific requirements and problems arising in embedded system applications.

Understanding architectures and components, their hardware-software interfaces, the memory architecture, communication between components, embedded operating systems, real-time scheduling theory, shared resources, low-power and low-energy design as well as hardware architecture synthesis.

Using the formal models and methods in embedded system design in practical applications using the programming language C, the operating system ThreadX, a commercial embedded system platform and the associated design environment.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. For example, they are part of industrial machines, agricultural and process industry devices, automobiles, medical equipment, cameras, household appliances, airplanes, sensor networks, internet-of-things, as well as mobile devices.

The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods. Besides, the lecture is complemented by laboratory sessions where students learn to program in C, to base their design on the embedded operating systems ThreadX, to use a commercial embedded system platform including sensors, and to edit/debug via an integrated development environment.

Specifically the following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://pbl.ee.ethz.ch/education/embedded-systems.html.

**Lecture notes**

The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at https://pbl.ee.ethz.ch/education/embedded-systems.html.
Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence,

Concepts of Object-Oriented Programming

Randomized Algorithms and Probabilistic Methods

Computer Graphics

Literature


Prerequisites / notice

Prerequisites: Basic knowledge in computer architectures and programming.

Abstract

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples.

Objective

This course aims at bridging the gap between mathematical modelers and clinical neuroscientists by teaching computational techniques in the context of clinical applications. The hope is that the acquisition of a joint language and tool-kit will enable more effective communication and joint translational research between fields that are usually worlds apart.

Content

This six-day course teaches state-of-the-art methods in computational psychiatry. It covers various computational models of cognition (e.g., learning and decision-making) and brain physiology (e.g., effective connectivity) of relevance for psychiatric disorders. The course not only provides theoretical background, but also demonstrates open source software in application to concrete examples. Furthermore, practical exercises provide in-depth exposure to different software packages. Please see http://www.translationalneuromodeling.org/cpcourse/ for details.

Abstract

Course that focuses on an in-depth understanding of object-oriented programming and compares designs of object-oriented programming languages. Topics include different flavors of type systems, inheritance models, encapsulation in the presence of aliasing, object and class initialization, program correctness, reflection

Objective

After this course, students will:

Have a deep understanding of advanced concepts of object-oriented programming and their support through various language features. Be able to understand language concepts on a semantic level and be able to compare and evaluate language designs. Be able to learn new languages more rapidly. Be aware of many subtle problems of object-oriented programming and know how to avoid them.

Content

The main goal of this course is to convey a deep understanding of the key concepts of sequential object-oriented programming and their support in different programming languages. This is achieved by studying how the modeling challenges are addressed through language features and programming idioms. In particular, the course discusses alternative language designs by contrasting solutions in languages such as C++, C#, Eiffel, Java, Python, and Scala. The course also introduces novel ideas from research languages that may influence the design of future mainstream languages.

The topics discussed in the course include among others:

- The pros and cons of different flavors of type systems (for instance, static vs. dynamic typing, nominal vs. structural, syntactic vs. behavioral typing)
- The key problems of single and multiple inheritance and how different languages address them
- Generic type systems, in particular, Java generics, C# generics, and C++ templates
- The situations in which object-oriented programming does not provide encapsulation, and how to avoid them
- The pitfalls of object initialization, exemplified by a research type system that prevents null pointer dereferencing
- How to maintain the consistency of data structures

Literature

Will be announced in the lecture.

Prerequisites / notice

Mastering at least one object-oriented programming language (this course will NOT provide an introduction to object-oriented programming); programming experience

Abstract

Las Vegas & Monte Carlo algorithms; inequalities of Markov, Chebyshev, Chernoff; negative correlation; Markov chains: convergence, rapidly mixing; generating functions; Examples include: min cut, median, balls and bins, routing in hypercubes, 3SAT, card shuffling, random walks

Objective

After this course students will know fundamental techniques from probabilistic combinatorics for designing randomized algorithms and will be able to apply them to solve typical problems in these areas.

Content

Randomized Algorithms are algorithms that "flip coins" to take certain decisions. This concept extends the classical model of deterministic algorithms and has become very popular and useful within the last twenty years. In many cases, randomized algorithms are faster, simpler or just more elegant than deterministic ones. In the course, we will discuss basic principles and techniques and derive from them a number of randomized methods for problems in different areas.

Lecture notes

Yes.

Literature


Abstract

This course covers some of the fundamental concepts of computer graphics generation of photorealistic images from digital representations of 3D scenes and image-based methods for recovering digital scene representations from captured images.

Objective

At the end of the course the students will be able to build a rendering system. The students will study the basic principles of rendering and image synthesis. In addition, the course is intended to stimulate the students' curiosity to explore the field of computer graphics in subsequent courses or on their own.

Content

This course covers fundamental concepts of modern computer graphics. Students will learn about 3D object representations and the details of how to generate photorealistic images from digital representations of 3D scenes. Starting with an introduction to 3D shape modeling, geometry representation and texture mapping, we will move on to the physics of light transport, acceleration structures, appearance modeling and Monte Carlo integration. We will apply these principles for computing light transport of direct and global illumination due to surfaces and participating media. We will end with an overview of modern image-based capture and image synthesis methods, covering topics such as geometry and material capture, light-fields and depth-image based rendering.
### Literature

Books:
- High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting
- Multiple view geometry in computer vision
- Physically Based Rendering: From Theory to Implementation

### Prerequisites / notice

**Prerequisites:**
- Fundamentals of calculus and linear algebra, basic concepts of algorithms and data structures, programming skills in C++, Visual Computing course recommended.
- The programming assignments will be in C++. This will not be taught in the class.

### 252-0546-00L

**Physically-Based Simulation in Computer Graphics**  
5 credits  
2V+1U+1A  
S. Coros, B. Thomaszewski, V. da Costa de Azevedo

**Abstract**
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

**Objectives**
This lecture provides an introduction to physically-based animation in computer graphics and gives an overview of fundamental methods and algorithms. The practical exercises include three assignments which are to be solved in small groups. In an additional course project, topics from the lecture will be implemented into a 3D game or a comparable application.

**Content**
The lecture covers topics in physically-based modeling, such as particle systems, mass-spring models, finite difference and finite element methods. These approaches are used to represent and simulate deformable objects or fluids with applications in animated movies, 3D games and medical systems. Furthermore, the lecture covers topics such as rigid body dynamics, collision detection, and character animation.

**Prerequisites / notice**
Fundamentals of calculus and physics, basic concepts of algorithms and data structures, basic programming skills in C++. Knowledge on numerical mathematics as well as ordinary and partial differential equations is an asset, but not required.

### 401-3621-00L

**Fundamentals of Mathematical Statistics**  
W  
10 credits  
4V+1U  
S. van de Geer

**Abstract**
The course covers the basics of inferential statistics.

**Objective**
Knowledge of methods and basic theory for high-dimensional statistical inference

**Content**
Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and ℓ₁ regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

**Literature**

**Prerequisites / notice**
Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

### 401-4623-00L

**Time Series Analysis**  
W  
4 credits  
2G  
N. Meinshausen

**Abstract**
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

**Objective**
The goal of the course is to have a a good overview of the different types of time series and the approaches used in their statistical analysis.

**Content**
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:
- Stationarity
- Autocorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

**Literature**
The main reference for this course is the book "Introduction to Time Series and Forecasting", by P. J. Brockwell and R. A. Davis

**Prerequisites / notice**
Basic knowledge in probability and statistics

### 401-3901-00L

**Linear & Combinatorial Optimization**  
W  
11 credits  
4V+2U  
R. Zenklusen

**Abstract**
Mathematical treatment of optimization techniques for linear and combinatorial optimization problems.

**Objective**
The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**
Key topics include:
- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**

**Prerequisites / notice**
Former course title: Mathematical Optimization.
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>Problem-solving</td>
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<tr>
<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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</tr>
<tr>
<td>Customer Orientation</td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>Negotiation</td>
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</tr>
<tr>
<td>Personal Competencies</td>
<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
<td>Integrity and Work Ethics</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>Self-direction and Self-management</td>
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</tbody>
</table>

### 401-4944-20L Mathematics of Data Science

**W 8 credits 4G A. Bandeira**

**Abstract**

Mostly self-contained, but fast-paced, introductory masters level course on various theoretical aspects of algorithms that aim to extract information from data.

**Objective**

Introduction to various mathematical aspects of Data Science.

**Content**

These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

**Lecture notes**


**Prerequisites / notice**

The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

### 227-0423-00L Neural Network Theory

**W 4 credits 2V+1U H. Bölcskei**

**Abstract**

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

**Objective**

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.

**Content**

1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

**Lecture notes**

Detailed lecture notes are available on the course web page

https://www.mins.ee.ethz.ch/teaching/nnt/

**Prerequisites / notice**

This course is aimed at students with a strong mathematical background in general, and in linear algebra, analysis, and probability theory in particular.

### 227-1033-00L Neuromorphic Engineering I

**W 6 credits 2V+3U T. Delbrück, G. Indiveri, S.-C. Liu**

Registration in this class requires the permission of the instructors. Class size will be limited to available lab spots. Preference is given to students that require this class as part of their major.

Information for UZH students:

Enrolment to this course unit only possible at ETH. No enrolment to module INI404 at UZH.

Please mind the ETH enrolment deadlines for UZH students: https://ethz.ch/en/studies/non-degree-courses/special-students.html
This course covers analog circuits with emphasis on neuromorphic engineering: MOS transistors in CMOS technology, static circuits, dynamic circuits, systems (silicon neuron, silicon retina, silicon cochlea) with an introduction to multi-chip systems. The lectures are accompanied by weekly laboratory sessions.

**Objective**
Understanding of the characteristics of neuromorphic circuit elements.

**Content**
Neuromorphic circuits are inspired by the organizing principles of biological neural circuits. Their computational primitives are based on physics of semiconductor devices. Neuromorphic architectures often rely on collective computation in parallel networks. Adaptation, learning and memory are implemented locally within the individual computational elements. Transistors are often operated in weak inversion (below threshold), where they exhibit exponential I-V characteristics and low currents. These properties lead to the feasibility of high-density, low-power implementations of functions that are computationally intensive in other paradigms. Application domains of neuromorphic circuits include silicon retinas and cochleas for machine vision and audition, real-time emulations of networks of biological neurons, and the development of autonomous robotic systems. This course covers devices in CMOS technology (MOS transistor below and above threshold, floating-gate MOS transistor, phototransducers), static circuits (differential pair, current mirror, transconductance amplifiers, etc.), dynamic circuits (linear and nonlinear filters, adaptive circuits), systems (silicon neuron, silicon retina and cochlea) and an introduction to multi-chip systems that communicate events analogous to spikes. The lectures are accompanied by weekly laboratory sessions on the characterization of neuromorphic circuits, from elementary devices to systems.

**Literature and Prerequisites**
S.-C. Liu et al.: Analog VLSI Circuits and Principles; various publications.

Prerequisites: Background in basics of semiconductor physics helpful, but not required.

**327-1201-00L Transport Phenomena I**

**Abstract**
Phenomenological approach to "Transport Phenomena" based on balance equations supplemented by thermodynamic considerations to formulate the undetermined fluxes in the local species mass, momentum, and energy balance equations; Solutions of a few selected problems relevant to materials science and engineering both analytical and using numerical methods.

**Objective**
The teaching goals of this course are on five different levels:
1. Deep understanding of fundamentals: local balance equations, constitutive equations for fluxes, entropy balance, interfaces, idea of dimensionless numbers and scaling,
2. Ability to use the fundamental concepts in applications
3. Insight into the role of boundary conditions (mainly part 2)
4. Knowledge of a number of applications.
5. Flavor of numerical techniques: finite elements and finite differences.

**Content**
Part 1 Approach to Transport Phenomena
Equilibrium Thermodynamics
Balance Equations
Forces and Fluxes
Applications
1. Measuring Transport Coefficients
2. Fluid mechanics
3. combined heat and flow

**Lecture notes**

**Literature**

**Prerequisites / notice**
Complex numbers. Vector analysis (integrability; Gauss’ divergence theorem). Laplace and Fourier transforms. Ordinary differential equations (basic ideas). Linear algebra (matrices; functions of matrices; eigenvectors and eigenvalues; eigenfunctions). Probability theory (Gaussian distributions; Poisson distributions; averages; moments; variances; random variables). Numerical mathematics (integration), Equilibrium thermodynamics (Gibbs’ fundamental equation; thermodynamic potentials; Legendre transforms). Maxwell equations.

**Fostered competencies**
Subject-specific Competencies: Concepts and Theories
Method-specific Competencies: Techniques and Technologies

**252-3005-00L Natural Language Processing**

**Abstract**
This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Objective**
The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

**Content**
This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as detailed exploration of the models and techniques used both in research and in commercial natural language systems.

**Literature**
Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

**263-2400-00L Reliable and Trustworthy Artificial Intelligence**

**Abstract**
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

**Objective**
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.
The course is split into 3 parts:

Robustness in Deep Learning
---------------------------------------
- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning
--------------------------------------
- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning
--------------------------------------
- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.


Prerequisites / notice
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

For solving assignments, some programming experience in Python is expected.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Problem-solving</td>
<td>Critical Thinking</td>
</tr>
</tbody>
</table>

see also Fields of Specialization

► Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-3667-72L</td>
<td>Case Studies Seminar (Autumn Semester 2022)</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>V. C. Gradinaru. R. Hiptmair</td>
</tr>
</tbody>
</table>

Abstract
Invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list. Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

Content
In the CSE Case Studies Seminar invited speakers from ETH, from other universities as well as from industry give a talk on an applied topic. Beside of attending the scientific talks students are asked to give short presentations (10 minutes) on a published paper out of a list (containing articles from, e.g., Nature, Science, Scientific American, etc.). If the underlying paper comprises more than 15 pages, two or three consecutive case studies presentations delivered by different students can be based on it. Consistency in layout, style, and contents of those presentations is expected.

Students have to register their presentations online on https://rw.ethz.ch/the-programme/case-studies.html by the first week of the teaching period.

Prerequisites / notice
The talks might be given via Zoom; talks in presence should be also streamed in Zoom.

75% attendance and a short presentation on a published paper out of a list or on some own project are mandatory.

Students have to register their presentations online until the second Wednesday of the semester on https://rw.ethz.ch/the-programme/case-studies.html

The student talks will be grouped by subject, so we'll decide the actual dates of the individual talks.

Students that realize that they will not fulfill this criteria have to contact the teaching staff or de-register before the end of semester from the Seminar if they want to avoid a “Fail” in their documents. Later de-registrations will not be considered.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
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<td>not assessed</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
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<td>not assessed</td>
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<td>Problem-solving</td>
<td>Project Management</td>
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<td></td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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</tbody>
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Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2047 of 2416
Semester Paper

There are several course units "Semester Paper" that are all equivalent. If, during your studies, you write several semester papers, choose among the different numbers in order to be able to obtain credits again.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3740-01L</td>
<td>Semester Paper ■ Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics or 402-2000-00L Scientific Works in Physics is required. For more information, see <a href="http://www.math.ethz.ch/intranet/students/study-administration/theses.html">www.math.ethz.ch/intranet/students/study-administration/theses.html</a> Supervisors only authorised for term papers must be assigned by the Study Administration.</td>
<td>W</td>
<td>8</td>
<td>17A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>401-3740-02L</td>
<td>Semester Paper (No. 2) ■ Successful participation in the course unit 401-2000-00L Scientific Works in Mathematics or 402-2000-00L Scientific Works in Physics is required. For more information, see <a href="http://www.math.ethz.ch/intranet/students/study-administration/theses.html">www.math.ethz.ch/intranet/students/study-administration/theses.html</a> Supervisors only authorised for term papers must be assigned by the Study Administration.</td>
<td>W</td>
<td>8</td>
<td>17A</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Science in Perspective

Two credits are needed from the "Science in Perspective" programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree. see https://ethz.ch/content/dam/ethz/common/docs/weisungsammlung/files-en/science-in-perspective.pdf (Eight credits must be acquired in this category: normally six during the Bachelor's degree programme, and two during the Master’s degree programme. A maximum of three credits from language courses can be recognised. Language courses from the range of the Language Center of the University of Zurich and ETH Zurich may be recognised. In addition, only advanced language courses from level C2 upwards.)

see Science in Perspective: Type A: Enhancement of Reflection Capability

see Science in Perspective: Type B for D-MATH

see Science in Perspective: Language Courses ETH/UZH

Master’s Thesis

If you wish to have recognised 402-2000-00L Scientific Works in Physics instead of 401-2000-00L Scientific Works in Mathematics (as allowed for the CSE programme), take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having passed the performance assessment.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-2000-00L</td>
<td>Scientific Works in Mathematics Target audience: Third year Bachelor students; Master students who cannot document to have received an adequate training in working scientifically.</td>
<td>O</td>
<td>0</td>
<td></td>
<td>D. Possamaï</td>
</tr>
<tr>
<td>401-2000-01L</td>
<td>Lunch Sessions – Thesis Basics for Mathematics Students Details and registration for the optional MathBib training course: <a href="https://www.math.ethz.ch/mathbib-schulungen">https://www.math.ethz.ch/mathbib-schulungen</a></td>
<td>Z</td>
<td>0</td>
<td></td>
<td>Speakers</td>
</tr>
<tr>
<td>402-2000-00L</td>
<td>Scientific Works in Physics Target audience: Master students who cannot document to have received</td>
<td>W</td>
<td>0</td>
<td></td>
<td>D. Kienzler</td>
</tr>
</tbody>
</table>
an adequate training in working scientifically.

Directive
https://www.ethz.ch/content/dam/ethz/common/docs/weis

Abstract
Literature Review: ETH-Library, Journals in Physics, Google Scholar; Thesis Structure: The IMRAD Model; Document Processing: LaTeX and BibTeX, Mathematical Writing, AVETH Survival Guide; ETH Guidelines for Integrity; Authorship Guidelines; ETH Citation Etiquettes; Declaration of Originality.

Objective
Basic standards for scientific works in physics: How to write a Master Thesis. What to know about research integrity.

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>401-4990-01L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>57D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Objective
Only students who fulfill the following criteria are permitted to commence the Master's thesis:
- a. successful completion of the Bachelor's programme;
- b. fulfilling of any additional requirements necessary to gain admission to the Master's programme;
- c. successful completion of
  1) at least two course units in the category 'Core courses';
  2) at least five course units, including a seminar, in the category 'Fields of specialisation'; and
  3) the semester paper.
Successful participation in the course unit 401-2000-00L, Scientific Works in Mathematics, or 402-2000-00L, Scientific Works in Physics is required.
For more information, see www.math.ethz.ch/intranet/students/study-administration/theses.html

Abstract
The master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.

Objective
Thesis work should prove the students' ability to independent, structured and scientific working.

Colloquia

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
Research colloquium

Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0363-AAL</td>
<td>Analysis III</td>
<td>E-</td>
<td>4</td>
<td>9R</td>
<td>A. Iozzi</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Introduction to partial differential equations. Differential equations which are important in applications are classified and solved. Elliptic, parabolic and hyperbolic differential equations are treated. The following mathematical tools are introduced: Laplace transforms, Fourier series, separation of variables, methods of characteristics.

Objective
Mathematical treatment of problems in science and engineering. To understand the properties of the different types of partial differential equations.

Content
Laplace Transforms:
- Laplace Transform, Inverse Laplace Transform, Linearity, s-Shifting
- Transforms of Derivatives and Integrals, ODEs
- Unit Step Function, t-Shifting
- Short Impulses, Dirac's Delta Function, Partial Fractions
- Convolution, Integral Equations
- Differentiation and Integration of Transforms

Fourier Series, Integrals and Transforms:
- Fourier Series
- Functions of Any Period p=2L
- Even and Odd Functions, Half-Range Expansions
- Forced Oscillations
- Approximation by Trigonometric Polynomials
- Fourier Integral
- Fourier Cosine and Sine Transform

Partial Differential Equations:
- Basic Concepts
- Modeling: Vibrating String, Wave Equation
- Solution by separation of variables; use of Fourier series
- D'Alembert Solution of Wave Equation, Characteristics
- Heat Equation: Solution by Fourier Series
- Heat Equation: Solutions by Fourier Integrals and Transforms
- Modeling Membrane: Two Dimensional Wave Equation
- Laplacian in Polar Coordinates: Circular Membrane, Fourier-Bessel Series
- Solution of PDEs by Laplace Transform
Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
- "Statistics for research" (online)
  Ch 1: The Role of Statistics
  Ch 2: Populations, Samples, and Probability Distributions
  Ch 3: Binomial Distributions
  Ch 6: Sampling Distribution of Averages
  Ch 7: Normal Distributions
  Ch 8: Student's t Distribution
  Ch 9: Distributions of Two Variables
- "Introductory Statistics with R (online)"
  Ch 1: Basics
  Ch 2: The R Environment
  Ch 3: Probability and distributions
  Ch 4: Descriptive statistics and tables
  Ch 5: One- and two-sample tests
  Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
  From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435
  From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m1757b/

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies
Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed
Personal Competencies
Self-direction and Self-management assessed
Literature


M. Hanke-Bourgeois “Grundlagen der Numerischen Mathematik und des wissenschaftlichen Rechnens”, BG Teubner, 2002


Prerequisites / notice

Solid knowledge about fundamental concepts and techniques from linear algebra & calculus as taught in the first year of science and engineering curricula.

The course will be accompanied by programming exercises in C++ relying on the template library EIGEN. Familiarity with C++, object oriented and generic programming is an advantage. Participants of the course are expected to learn C++ by themselves.

401-0674-AAL

Numerical Methods for Partial Differential Equations

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Derivation, properties, and implementation of fundamental numerical methods for a few key partial differential equations: convection-diffusion, heat equation, wave equation, conservation laws. Implementation in C++ based on a finite element library.

Objective

Main skills to be acquired in this course:

* Ability to implement fundamental numerical methods for the solution of partial differential equations efficiently.
* Ability to modify and adapt numerical algorithms guided by awareness of their mathematical foundations.
* Ability to select and assess numerical methods in light of the predictions of theory
* Ability to identify features of a PDE (= partial differential equation) based model that are relevant for the selection and performance of a numerical algorithm.
* Ability to understand research publications on theoretical and practical aspects of numerical methods for partial differential equations.
* Skills in the efficient implementation of finite element methods on unstructured meshes.

This course is neither a course on the mathematical foundations and numerical analysis of methods nor an course that merely teaches recipes and how to apply software packages.
Content
1 Case Study: A Two-point Boundary Value Problem [optional]
1.1 Introduction
1.2 A model problem
1.3 Variational approach
1.4 Simplified model
1.5 Discretization
1.5.1 Galerkin discretization
1.5.2 Collocation [optional]
1.5.3 Finite differences
1.6 Convergence
2 Second-order Scalar Elliptic Boundary Value Problems
2.1 Equilibrium models
2.1.1 Taut membrane
2.1.2 Electrostatic fields
2.1.3 Quadratic minimization problems
2.2 Sobolev spaces
2.3 Variational formulations
2.4 Equilibrium models: Boundary value problems
3 Finite Element Methods (FEM)
3.1 Galerkin discretization
3.2 Case study: Triangular linear FEM in two dimensions
3.3 Building blocks of general FEM
3.4 Lagrangian FEM
3.4.1 Simplicial Lagrangian FEM
3.4.2 Tensor-product Lagrangian FEM
3.5 Implementation of FEM in C++
3.5.1 Mesh file format (Gmsh)
3.5.2 Mesh data structures (DUNE)
3.5.3 Assembly
3.5.4 Local computations and quadrature
3.5.5 Incorporation of essential boundary conditions
3.6 Parametric finite elements
3.6.1 Affine equivalence
3.6.2 Example: Quadrilateral Lagrangian finite elements
3.6.3 Transformation techniques
3.6.4 Boundary approximation
3.7 Linearization [optional]
4 Finite Differences (FD) and Finite Volume Methods (FVM) [optional]
4.1 Finite differences
4.2 Finite volume methods (FVM)
5 Convergence and Accuracy
5.1 Galerkin error estimates
5.2 Empirical Convergence of FEM
5.3 Finite element error estimates
5.4 Elliptic regularity theory
5.5 Variational crimes
5.6 Duality techniques [optional]
5.7 Discrete maximum principle [optional]
6 2nd-Order Linear Evolution Problems
6.1 Parabolic initial-boundary value problems
6.1.1 Heat equation
6.1.2 Spatial variational formulation
6.1.3 Method of lines
6.1.4 Timestepping
6.1.5 Convergence
6.2 Wave equations [optional]
6.2.1 Vibrating membrane
6.2.2 Wave propagation
6.2.3 Method of lines
6.2.4 Timestepping
6.2.5 CFL-condition
7 Convection-Diffusion Problems [optional]
7.1 Heat conduction in a fluid
7.1.1 Modelling fluid flow
7.1.2 Heat convection and diffusion
7.1.3 Incompressible fluids
7.1.4 Transient heat conduction
7.2 Stationary convection-diffusion problems
7.2.1 Singular perturbation
7.2.2 Upwinding
7.3 Transient convection-diffusion BVP
7.3.1 Method of lines
7.3.2 Transport equation
7.3.3 Lagrangian split-step method
7.3.4 Semi-Lagrangian method
8 Numerical Methods for Conservation Laws
8.1 Conservation laws: Examples
8.2 Scalar conservation laws in 1D
8.3 Conservative finite volume discretization
8.3.1 Semi-discrete conservation form
8.3.2 Discrete conservation property
8.3.3 Numerical flux functions
8.3.4 Monotone schemes
8.4 Timestepping
8.4.1 Linear stability
8.4.2 CFL-condition
8.4.3 Convergence
8.5 Higher order conservative schemes [optional]
8.5.1 Slope limiting
8.5.2 MUSCL scheme
8.6. FV-schemes for systems of conservation laws [optional]

"optional" indicates that the corresponding topic might be skipped depending on the progress of the course.

Lecture notes
The lecture will be taught in flipped classroom format:
- Video tutorials for all thematic units will be published online.
- Solution of homework problems will partly be covered by video tutorials.
- Lecture documents and tablet notes accompanying the videos will be made available to the audience as PDF.

Literature
Chapters of the following books provide supplementary reading (detailed references in course material):


However, study of supplementary literature is not important for following the course.

Prerequisites / notice
Mastery of basic calculus and linear algebra is taken for granted.
Familiarity with fundamental numerical methods (solution methods for linear systems of equations, interpolation, approximation, numerical quadrature, numerical integration of ODEs) is essential.

Important: Coding skills and experience in C++ are essential.

Homework assignments involve substantial coding, partly based on a C++ finite element library. The written examination will be computer based and will comprise coding tasks.

Software Engineering
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course introduces both theoretical and applied aspects of software engineering. It covers:
- Software Architecture
- Informal and formal Modeling
- Design Patterns
- Software Engineering Principles
- Code Refactoring
- Program Testing

Objective
The course has two main objectives:
- Obtain an end-to-end (both, theoretical and practical) understanding of the core techniques used for building quality software.
- Be able to apply these techniques in practice.

Content
While the lecture will provide the theoretical foundations for the various aspects of software engineering, the students will apply those techniques in project work that will span over the whole semester - involving all aspects of software engineering, from understanding requirements over design and implementation to deployment and change requests.

Literature
Will be announced in the lecture

Computational Science and Engineering Master - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<th>Key for Hours</th>
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<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
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<tbody>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

ECTS
European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
### Core Courses

#### 151-0107-20L High Performance Computing for Science and Engineering (HPCESE)

**Abstract**
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

**Objective**
With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

**Content**
2. Distributed memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP).
3. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
4. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods.

**Lecture notes**
https://www.cse-lab.ethz.ch/teaching/hpcese-i_hs22/

**Literature**
- Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
- Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
- Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
- Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
- Lecture notes

**Prerequisites / notice**
Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

#### 151-0325-00L Planning and Decision Making for Autonomous Robots

**Abstract**
Planning safe and efficient motions for robots in complex environments, often shared with humans and other robots, is a difficult problem combining discrete and continuous mathematics, as well as probabilistic, game-theoretic, and ethical/regulatory aspects. This course will cover the algorithmic foundations of motion planning, with an eye to real-world implementation issues.

**Objective**
The students will learn how to design and implement state-of-the-art algorithms for planning the motion of robots executing challenging tasks in complex environments.

**Content**

**Lecture notes**
Course notes and other education material will be provided for free in an electronic form.

**Literature**
There is no required textbook, but an excellent reference is Steve LaValle's book on "Planning Algorithms."

**Prerequisites / notice**
Students should have taken basic courses in optimization, control systems, probability theory, and should be familiar with modern programming languages and practices (e.g., Python, and/or C/C++). Previous exposure to robotic systems is a definite advantage.

**Fostered competencies**
Subject-specific Competencies: Concepts and Theories, Techniques and Technologies

#### 151-0371-00L Advanced Model Predictive Control

**Abstract**
Model predictive control (MPC) has established itself as a powerful control technique for complex systems under state and input constraints. This course discusses the theory and application of advanced MPC concepts, focusing on system uncertainties and safety, as well as data-driven formulations and learning-based control.

**Objective**
Design, implement and analyze advanced MPC formulations for robust and stochastic uncertainty descriptions, in particular with data-driven formulations.

**Content**
Topics include:
- Nominal MPC for uncertain systems (nominal robustness)
- Robust MPC
- Stochastic MPC
- Review of regression methods
- Set-membership Identification and robust data-driven MPC
- Bayesian regression and stochastic data-driven MPC
- MPC as safety filter for reinforcement learning

**Lecture notes**
Lecture notes will be provided.

**Prerequisites / notice**
Basic courses in control, advanced course in optimal control, basic MPC course (e.g. 151-0660-00L Model Predictive Control) strongly recommended. Background in linear algebra and stochastic systems recommended.

#### 151-0509-00L Acoustics in Fluid Media: From Robotics to Additive Manufacturing

**Abstract**
The course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

**Prerequisites / notice**
Note: The previous course title until HS21 “Microscale Acoustofluidics”
Microrobotics is an interdisciplinary field that combines aspects of robotics, micro and nanotechnology, biomedical engineering, and materials science. The aim of this course is to expose students to the fundamentals of this emerging field. Throughout the course, the students apply these concepts in assignments. The course concludes with an end-of-semester examination.
Objective
The objective of this course is to expose students to the fundamental aspects of the emerging field of micro-robotics. This includes a focus on physical laws that predominate at the microscale, technologies for fabricating small devices, bio-inspired design, and applications of the field.

Content
Main topics of the course include:
- Scaling laws at micro/nano scales
- Electrostatics
- Electromagnetics
- Low Reynolds number flows
- Observation tools
- Materials and fabrication methods
- Applications of biomedical micro-robots

Lecture notes
The powerpoint slides presented in the lectures will be made available as pdf files. Several readings will also be made available electronically.

Prerequisites / notice
The lecture will be taught in English.

151-0632-00L  
**Vision Algorithms for Mobile Robotics (University of Zurich)**

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

**UZH Module Code:** DINF2039

*Mind the enrolment deadlines at UZH:*
https://www.uzh.ch/cmsssl/en/studies/application/deadline.html

**Abstract**
For a robot to be autonomous, it has to perceive and understand the world around it. This course introduces you to the key computer vision algorithms used in mobile robotics, such as feature extraction, structure from motion, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry (the algorithms behind Hololens, Oculus Quest, and the NASA Mars rovers).

**Objective**
Learn the fundamental computer vision algorithms used in mobile robotics, in particular: filtering, feature extraction, structure from motion, multiple view geometry, dense reconstruction, tracking, image retrieval, event-based vision, and visual-inertial odometry and Simultaneous Localization And Mapping (SLAM) (the algorithms behind Hololens, Facebook-Oculus Quest, and the NASA Mars rovers).

**Content**
Each lecture will be followed by a lab session where you will learn to implement a building block of a visual odometry algorithm in Matlab.

By the end of the course, you will integrate all these building blocks into a working visual odometry algorithm.

**Lecture notes**
Lecture slides will be made available on the course official website: http://rpg.ifi.uzh.ch/teaching.html

**Literature**

**Prerequisites / notice**
Fundamentals of algebra, geometry, matrix calculus, and Matlab programming.

151-0851-00L  
**Robot Dynamics**

We will provide an overview on how to kinematically and dynamically model typical robotic systems such as robot arms, legged robots, rotary wing systems, or fixed wing.

**Abstract**
The primary objective of this course is that the student deepens an applied understanding of how to model the most common robotic systems. The student receives a solid background in kinematics, dynamics, and rotations of multi-body systems. On the basis of state of the art applications, he/she will learn all necessary tools to work in the field of design or control of robotic systems.

**Objective**
The course consists of three parts: First, we will refresh and deepen the student's knowledge in kinematics, dynamics, and rotations of multi-body systems. In this context, the learning material will build upon the courses for mechanics and dynamics available at ETH, with the particular focus on their application to robotic systems. The goal is to foster the conceptual understanding of similarities and differences among the various types of robots. In the second part, we will apply the learned material to classical robotic arms as well as legged systems and discuss kinematic constraints and interaction forces. In the third part, focus is put on modeling fixed wing aircraft, along with related design and control concepts. In this context, we also touch aerodynamics and flight mechanics to an extent typically required in robotics. The last part finally covers different helicopter types, with a focus on quadrotors and the coaxial configuration which we see today in many UAV applications. Case studies on all main topics provide the link to real applications and to the state of the art in robotics.

**Content**
The contents of the following ETH Bachelor lectures or equivalent are assumed to be known: Mechanics and Dynamics, Control, Basics in Fluid Dynamics.

151-1116-00L  
**Introduction to Aircraft and Car Aerodynamics**

Airplane aerodynamics: Atmosphere; aerodynamic forces (lift, drag); thrust.

**Abstract**
An introduction to the basic principles and interrelationships of aircraft and automotive aerodynamics.
To understand the basic relations of the origin of aerodynamic forces (ie lift, drag). To quantify the aerodynamic forces for basic configurations of aircraft and car components.
Illustration of the intrinsic problems and results using examples.
Using experimental and theoretical methods to illustrate possibilities and limits.

**Objective**
Aircraft aerodynamics: atmosphere, aerodynamic forces (ascending force; profile, wings, Resistance, residual resistance, induced resistance); thrust (overview of the propulsion system, aerodynamics of the propellers), introduction to static longitudinal stability.

**Content**
Lecture notes
Preparation materials & slides are provided prior to each class

Literature
Aircraft Aerodynamics:
- Synching H. H. und Truckenbrodt, E: Aerodynamik des Flugzeuge (Bd I und II), Springer Verlag, 1960
- Hoerner, S.F.: Fluid Dynamic Lift, Hoerner Fluid Dynamics, 1975

Vehicle Aerodynamics

151-0532-00L  Nonlinear Dynamics and Chaos I  W  4 credits  2V+2U  G. Haller

Abstract
Basic facts about nonlinear systems; stability and near-equilibrium dynamics; bifurcations; dynamical systems on the plane; non-autonomous dynamical systems; chaotic dynamics.

Objective
This course is intended for Masters and Ph.D. students in engineering sciences, physics and applied mathematics who are interested in the behavior of nonlinear dynamical systems. It offers an introduction to the qualitative study of nonlinear physical phenomena modeled by differential equations or discrete maps. We discuss applications in classical mechanics, electrical engineering, fluid mechanics, and biology. A more advanced Part II of this class is offered every other year.

Content
(1) Basic facts about nonlinear systems: Existence, uniqueness, and dependence on initial data.
(2) Near equilibrium dynamics: Linear and Lyapunov stability
(3) Bifurcations of equilibria: Center manifolds, normal forms, and elementary bifurcations
(4) Nonlinear dynamical systems on the plane: Phase plane techniques, limit sets, and limit cycles.
(5) Time-dependent dynamical systems: Floquet theory, Poincare maps, averaging methods, resonance

Lecture notes
The class lecture notes will be posted electronically after each lecture. Students should not rely on these but prepare their own notes during the lecture.

Prerequisites / notice
- Prerequisites: Analysis, linear algebra and a basic course in differential equations.
- Exam: two-hour written exam in English.
- Homework: A homework assignment will be due roughly every other week. Hints to solutions will be posted after the homework due dates.

151-9905-00L  Applied Compositional Thinking for Engineers II  W  4 credits  3G  A. Censi, J. Lorand

Abstract
This course is an introduction to advanced topics in Applied Category Theory focused on the needs of applications. The course favors a computational, constructive, and compositional approach targeted to applications in engineering.

Objective
In many domains of engineering and applied sciences, it would be beneficial to think explicitly about abstraction and compositionality, to improve both the understanding of problems and the design of solutions. Applied Category Theory is a field of mathematics that can help in thinking about precisely such topics. A problem, however, is that this type of mathematics is not traditionally taught -- to date, there exists no easy path for engineers to learn category theory that is approachable and emphasizes engineering applications. This course will fill this gap, extending the efforts proposed in the first part of the class (ACT4E I).

This course's goal is not to teach category theory for the sake of it, but to teach the "compositional way of thinking". Category theory will just be the means towards this end. This implies that the presentation of materials sometimes diverges from the usual way to teach category theory, and some common concepts might be de-emphasized in favor of more obscure concepts that are more useful for applications.

The applications shown in the class will be mainly in the domains of autonomous robotics and mobility.

Content
Categories
Functors
Co-design problems
Natural transformations
Adjunctions
Traced monoidal categories
Computation:
- From mathematical models to algorithms
- Solving finite co-design problems
- Monads
- Modeling uncertainty
Enriched category theory:
- Profunctors
- Enriched categories
- Negative category theory
Operads

Lecture notes
Slides and notes will be provided.

Literature
Censi, Lorand, Zardini, Applied Compositional Thinking for Engineers (https://bit.ly/3qQnrRt)
Prerequisites / notice

The course is self-contained and can be taken, in principle, without ACT4E I.

We assume this knowledge:
1) Basics of logic & mathematical thinking, ability to write simple mathematical proofs.
2) Basic algebra (sets, posets, relations, semigroups, groups).

Students who took 151-9904-00L Applied Compositional Thinking for Engineers I in the Spring Semester are sufficiently proficient in (1) and (2).

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0102-00L</td>
<td>Discrete Event Systems</td>
<td>W</td>
<td>6</td>
<td>L. Josipovic, L. Vanbever, R. Wattenhofer</td>
</tr>
</tbody>
</table>

Abstract
Introduction to discrete event systems. We start out by studying popular models of discrete event systems. In the second part of the course we analyze discrete event systems from an average-case and from a worst-case perspective. Topics include: Automata and Languages, Specification Models, Stochastic Discrete Event Systems, Worst-Case Event Systems, Verification, Network Calculus.

Objective
Over the past few decades the rapid evolution of computing, communication, and information technologies has brought about the proliferation of new dynamic systems. A significant part of activity in these systems is governed by operational rules designed by humans. The dynamics of these systems are characterized by asynchronous occurrences of discrete events, some controlled (e.g. hitting a keyboard key, sending a message), some not (e.g. spontaneous failure, packet loss).

The mathematical arsenal centered around differential equations that has been employed in systems engineering to model and study processes governed by the laws of nature is often inadequate or inappropriate for discrete event systems. The challenge is to develop new modeling frameworks, analysis techniques, design tools, testing methods, and optimization processes for this new generation of systems.

In this lecture we give an introduction to discrete event systems. We start out the course by studying popular models of discrete event systems, such as automata and Petri nets. In the second part of the course we analyze discrete event systems. We first examine discrete event systems from an average-case perspective: we model discrete events as stochastic processes, and then apply Markov chains and queuing theory for an understanding of the typical behavior of a system. In the last part of the course we analyze discrete event systems from a worst-case perspective using the theory of online algorithms and adversarial queuing.

Content
1. Introduction
2. Automata and Languages
3. Smarter Automata
4. Specification Models
5. Stochastic Discrete Event Systems
6. Worst-Case Event Systems
7. Network Calculus

Lecture notes
Available

Literature

[bertsekas] Data Networks
Dimitri Bertsekas, Robert Gallager

[borodin] Online Computation and Competitive Analysis
Allan Borodin, Ran El-Yaniv.
Cambridge University Press, 1998

[boudec] Network Calculus
J.-Y. Le Boudec, P. Thiran
Springer, 2001

[cassandras] Introduction to Discrete Event Systems
Christos Cassandras, Stéphane Lafortune.

[fiat] Online Algorithms: The State of the Art
A. Fiat and G. Woeginger

D. Hochbaum

[schickinger] Diskrete Strukturen (Band 2: Wahrscheinlichkeitstheorie und Statistik)
T. Schickinger, A. Steger
Springer, Berlin, 2001

[sipser] Introduction to the Theory of Computation
Michael Sipser.

227-0124-00L Embedded Systems

Abstract
An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions.

Objective
Understanding specific requirements and problems arising in embedded system applications.

Understanding architectures and components, their hardware-software interfaces, the memory architecture, communication between components, embedded operating systems, real-time scheduling theory, shared resources, low-power and low-energy design as well as hardware architecture synthesis.

Using the formal models and methods in embedded system design in practical applications using the programming language C, the operating system ThreadX, a commercial embedded system platform and the associated design environment.
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

The following topics will be covered in the course: Embedded system architectures and components, hardware-software interfaces and memory architecture, software design methodology, communication, embedded operating systems, real-time scheduling, shared resources, low-power and low-energy design, hardware architecture synthesis.

More information is available at https://pbl.ee.ethz.ch/education/embedded-systems.html.

The following information will be available: Lecture material, publications, exercise sheets and laboratory documentation at https://pbl.ee.ethz.ch/education/embedded-systems.html.

Available on the course Moodle platform.

Prerequisites: Basic knowledge in computer architectures and programming.

227-0225-00L Linear System Theory 6 credits 5G J. Lygeros, A. Tsiami

Objective
Students should be able to apply the fundamental results in linear system theory to analyze and control linear dynamical systems.

Abstract
The class is intended to provide a comprehensive overview of the theory of linear dynamical systems, stability analysis, and their use in control and estimation. The focus is on the mathematics behind the physical properties of these systems and on understanding and optimizing properties of linear control systems.

Content
- Proof techniques and practices.
- Linear spaces, normed linear spaces and Hilbert spaces.
- Ordinary differential equations, existence and uniqueness of solutions.
- Continuous and discrete-time, time-varying linear systems. Time domain solutions. Time invariant systems treated as a special case.
- Controllability and observability, duality. Time invariant systems treated as a special case.
- Stability and stabilization, observers, state and output feedback, separation principle.

227-0247-00L Power Electronic Systems I 6 credits 4G J. Biela, F. Krismer

Objective
Detailed understanding of the principle of operation and modulation of advanced power electronics converter systems, especially of zero voltage switching and zero current switching non-isolated and isolated DC/DC converter systems and three-phase voltage DC link inverter systems. Furthermore, the course should convey knowledge on the switching frequency related losses of power semiconductors and inductive power components and introduce the concept of space vector calculus which provides a basis for the comprehensive discussion of three-phase PWM converters systems in the lecture Power Electronic Systems II.

Abstract
Basics of the switching behavior, gate drive and snubber circuits of power semiconductors are discussed. Soft-switching and resonant DC/DC converters are analyzed in detail and high frequency loss mechanisms of magnetic components are explained. Space vector modulation of three-phase inverters is introduced and the main power components are designed for typical industry applications.

Content
Basics of the switching behavior and gate drive circuits of power semiconductor devices and auxiliary circuits for minimizing the switching losses are explained. Furthermore, zero voltage switching, zero current switching, and resonant DC/DC converters are discussed in detail; the operating behavior of isolated full-bridge DC/DC converters is detailed for different secondary side rectifier topologies; high frequency loss mechanisms of magnetic components of converter circuits are explained and approximate calculation methods are presented; the concept of space vector calculus for analyzing three-phase systems is introduced; finally, phase-oriented and space vector modulation of three-phase inverter systems are discussed related to voltage DC link inverter systems and the design of the main power components based on analytical calculations is explained.

227-0447-00L Image Analysis and Computer Vision 6 credits 3V+1U E. Konukoglu, F. Yu

Objective
Overview of the most important concepts of image formation, perception and analysis, and Computer Vision. Gaining own experience through practical computer and programming exercises.
The goal of this course is understanding the stationary and dynamic problems in electrical power systems. The course includes the development of stationary models of the electrical network, their mathematical representation and special characteristics and solution methods of large linear and non-linear systems of equations related to electrical power networks.

Content

The course language is English.

Prerequisites

Basic concepts of mathematical analysis and linear algebra. The computer exercises are based on Python and Linux.

Lecture notes

Course material, script, computer demonstrations, exercises and problem solutions.

References

IEC61131-3.

Practical exercises will illustrate some topics, e.g., some control software coding using industry standard programming tools based on IEC61131-3.

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Practical exercises will be illustrated by some topics, e.g., some control software coding using industry standard programming tools based on IEC61131-3.

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

The course provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context, students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

<table>
<thead>
<tr>
<th>252-3110-00L</th>
<th>Human Computer Interaction</th>
<th>W</th>
<th>6 credits</th>
<th>2V+1U+2A</th>
<th>C. Holz, O. Hilliges</th>
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<tbody>
<tr>
<td>252-5051-00L</td>
<td>Advanced Topics in Machine Learning</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>J. M. Buhmann, R. Cotterell, N. He, F. Yang, M. Ellassady</td>
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<tr>
<td>252-5701-00L</td>
<td>Seminar in Advanced Topics in Vision</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>M. Pollefeys, S. Tang</td>
</tr>
</tbody>
</table>

The course provides an introduction to the field of human-computer interaction, emphasising the central role of the user in system design. Through detailed case studies, students will be introduced to different methods used to analyse the user experience and shown how these can inform the design of new interfaces, systems and technologies.

The goal of the course is that students should understand the principles of user-centred design and be able to apply these in practice. As well as understand the basic notions of Computational Design in a HCI context, students will get experience of designing and carrying out user studies as well as analysing results. The course will also cover the basic principles of interaction design. Practical exercises related to touch and gesture-based interaction will be used to reinforce the concepts introduced in the lecture. To get students to further think beyond traditional system design, we will discuss issues related to ambient information and awareness.

The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

The seminar covers advanced topics in computer vision, such as 3D reconstruction, image understanding, object detection, people tracking, motion prediction, and other related topics. Each time the course is offered, a collection of research papers is selected and each student presents one paper to the class and leads a discussion about the paper and related topics.

The goal is to get an in-depth understanding of actual problems and research topics in the field of computer vision as well as improve presentations and critical analysis skills.
<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites</th>
<th>Literature</th>
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<tr>
<td>263-5210-00L</td>
<td>Probabilistic Artificial Intelligence</td>
<td>8</td>
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<tr>
<td>Objective</td>
<td>How can we build systems that perform well in uncertain environments? How can we develop systems that exhibit &quot;intelligent&quot; behavior, without prescribing explicit rules? How can we build systems that learn from experience in order to improve their performance? We will study core modeling techniques and algorithms from machine learning, optimization, planning, and control and study applications in areas such as robotics. The course is designed for graduate students.</td>
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<tr>
<td>Content</td>
<td>Topics covered:</td>
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<td></td>
<td>- Probability</td>
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<td>- Probabilistic inference (variational inference, MCMC)</td>
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<td>- Bayesian learning (Gaussian processes, Bayesian deep learning)</td>
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<td>- Probabilistic planning (MDPs, POMDPs)</td>
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<td></td>
<td>- Multi-arm bands and Bayesian optimization</td>
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<td>- Reinforcement learning</td>
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<td>Prerequisites / notice</td>
<td>Solid basic knowledge in statistics, algorithms and programming.</td>
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<td></td>
<td>The material covered in the course &quot;Introduction to Machine Learning&quot; is considered as a prerequisite.</td>
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<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>8</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
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<tr>
<td>Objective</td>
<td>The objectives of this course are:</td>
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<tr>
<td></td>
<td>1. To introduce the fundamental problems of computer vision.</td>
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<td>2. To introduce the main concepts and techniques used to solve those.</td>
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<td>3. To enable participants to implement solutions for reasonably complex problems.</td>
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<td>4. To enable participants to make sense of the computer vision literature.</td>
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<td>Content</td>
<td>Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Solid basic knowledge in statistics, algorithms and programming.</td>
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<td>The material covered in the course &quot;Introduction to Machine Learning&quot; is considered as a prerequisite.</td>
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<tr>
<td>263-5905-00L</td>
<td>Mixed Reality</td>
<td>5</td>
<td>3G+1A</td>
<td>I. Armeni, M. Pollefeys</td>
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<tr>
<td>Objective</td>
<td>After attending this course, students will:</td>
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<tr>
<td></td>
<td>1. Understand the foundations of 3D graphics, Computer Vision, and Human-Machine Interaction</td>
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<td>2. Have a clear understanding on how to build mixed reality apps</td>
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<td>3. Have a good overview of state-of-the-art Mixed Reality</td>
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<td>4. Be able to critically analyze and assess current research in this area.</td>
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<tr>
<td>Content</td>
<td>The course introduces latest mixed reality technology and provides introductory elements for a number of related fields including:</td>
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<td></td>
<td>Introduction to Mixed Reality / Augmented Reality / Virtual Reality Introduction to 3D Computer Graphics, 3D Computer Vision. This will take place in the form of short lectures, followed by student presentations discussing the current state-of-the-art. The main focus of this course are student projects on mixed reality topics, where small groups of students will work on a particular project with the goal to design, develop and deploy a mixed reality application. The project topics are flexible and can reach from proof-of-concept vision/graphics/HMI research, to apps that support teaching with interactive augmented reality, or game development. The default platform will be Microsoft HoloLens in combination with C# and Unity3D - other platforms are also possible to use, such as tablets and phones.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Solid basic knowledge in statistics, algorithms and programming.</td>
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<tr>
<td></td>
<td>The material covered in the course &quot;Introduction to Machine Learning&quot; is considered as a prerequisite.</td>
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<tr>
<td>376-1504-00L</td>
<td>Physical Human Robot Interaction (pHRI)</td>
<td>4</td>
<td>2V+2U</td>
<td>O. Lamberry</td>
</tr>
<tr>
<td>Objective</td>
<td>The objective of this course is to give an introduction to the fundamentals of physical human robot interaction, through lectures on the underlying theoretical/mechatronics aspects and application fields, in combination with a hands-on lab tutorial. The course will guide students through the design and evaluation process of such systems.</td>
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<td>By the end of this course, you should understand the critical elements in human-robot interactions - both in terms of engineering and human factors - and use these to evaluate and de- sign safe and efficient assistive and rehabilitative robotic systems. Specifically, you should be able to:</td>
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<tr>
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<td>1) identify critical human factors in physical human-robot interaction and use these to derive design requirements;</td>
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<td>2) compare and select mechatronic components that optimally fulfill the defined design requirements;</td>
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<td>3) derive a model of the device dynamics to guide and optimize the selection and integration of selected components into a functional system;</td>
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<td>4) design control hardware and software and implement and test human-interactive control strategies on the physical setup;</td>
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<td>5) characterize and optimize such systems using both engineering and psychophysical evaluation metrics;</td>
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<td>6) investigate and optimize one aspect of the physical setup and convey and defend the gained insights in a technical presentation.</td>
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</table>
This course provides an introduction to fundamental aspects of physical human-robot interaction. After an overview of human haptic, visual and auditory sensing, neurophysiology and psychophysics, principles of human-robot interaction systems (kinematics, mechanical transmissions, robot sensors and actuators used in these systems) will be introduced. Throughout the course, students will gain knowledge of interaction control strategies including impedance/admittance and force control, haptic rendering basics and issues in device design for humans such as transparency and stability analysis, safety hardware and procedures. The course is organized into lectures that aim to bring students up to speed with the basics of these systems, readings on classical and current topics in physical human-robot interaction, laboratory sessions and tab labs.

Students will attend periodic laboratory sessions where they will implement the theoretical aspects learned during the lectures. Here the salient features of haptic device design will be identified and theoretical aspects will be haptic developed in a haptic system based on the haptic paddle (https://relab.ethz.ch/downloads/open-hardware/haptic-paddle.html), by creating simple dynamic haptic virtual environments and understanding the performance limitations and causes of instabilities (direct/virtual coupling, friction, damping, time delays, sampling rate, sensor quantization, etc.) during rendering of different mechanical properties.

Lecture notes
Will be distributed on Moodle before the lectures.

Literature

Prerequisites / notice
The registration is limited to 26 students
There are 4 credit points for this lecture.
The lecture will be held in English.
The students are expected to have basic control knowledge from previous classes.
http://www.relab.ethz.ch/education/courses/phi.html

Data: 01.11.2022 12:41   Autumn Semester 2022   Page 2063 of 2416
Any courses offered by the Departments of MAVT, ITET or INFK. Your tutor must agree to this choice.

151-0623-00L ETH Zurich Distinguished Seminar in Robotics, Systems and Controls

Abstract
This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls.

Objective
Obtain an overview of various topics in Robotics, Systems, and Controls from leaders in the field. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a list of upcoming lectures.

Content
This course consists of a series of seven lectures given by researchers who have distinguished themselves in the area of Robotics, Systems, and Controls. MSc students in Robotics, Systems, and Controls are required to attend every lecture. Attendance will be monitored. If for some reason a student cannot attend one of the lectures, the student must select another ETH or University of Zurich seminar related to the field and submit a one page description of the seminar topic. Please see http://www.msrl.ethz.ch/education/distinguished-seminar-in-robotics--systems--controls--151-0623-0.html for a suggestion of other lectures.

Prerequisites / notice
Students are required to attend all seven lectures to obtain credit. If a student must miss a lecture then attendance at a related special lecture will be accepted that is reported in a one page summary of the attended lecture. No exceptions to this rule are allowed.

► Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

► Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1014-00L</td>
<td>Semester Project Robotics, Systems and Control Only for Robotics, Systems and Control MSc.</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
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</tbody>
</table>

Abstract
The subject of the Semester Project and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

Objective
The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

► Industrial Internship

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship Access to the company list and request for recognition under <a href="http://www.mavt.ethz.ch/praxis">www.mavt.ethz.ch/praxis</a>.</td>
<td>O</td>
<td>8 credits</td>
<td></td>
<td>external organisers</td>
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</tbody>
</table>

Abstract
No registration required via myStudies.

Objective
The main objective of the minimum twelve-week internship is to expose Master's students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

► Master's Thesis

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
</table>
| 151-1016-00L | Master's Thesis Robotics, Systems and Control Students who fulfill the following criteria are allowed to begin with their Master's Thesis:
   a. successful completion of the bachelor program;
   b. fulfilling of any additional requirements necessary to gain admission to the master programme;
   c. successful completion of the semester project;
   d. achievement of 28 ECTS in the category "Core Courses".
   The Master's Thesis must be approved in advance by the tutor and is supervised by a professor of ETH Zurich or an adjunct faculty of RSC. | O    | 30 credits | 64D   | Professors |

Abstract
Master's programs are concluded by the master's thesis. The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem. The subject of the master's thesis, as well as the project plan and roadmap, are proposed by the tutor and further elaborated with the student.

Objective
The thesis is aimed at enhancing the student's capability to work independently toward the solution of a theoretical or applied problem.

Robotics, Systems and Control Master - Key for Type

| O | Compulsory |
| W | Eligible for credits and recommended |
| W | Eligible for credits |

E- Recommended, not eligible for credits
Z Courses outside the curriculum
Dr Suitable for doctorate
<table>
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<tr>
<th>Key for Hours</th>
<th>Description</th>
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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
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<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
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<tr>
<td>K</td>
<td>colloquium</td>
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<tr>
<td>P</td>
<td>practical/laboratory course</td>
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<tr>
<td>A</td>
<td>independent project</td>
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<tr>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>R</td>
<td>revision course / private study</td>
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</table>

ECTS European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Science, Technology, and Policy Master

#### Social Sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td></td>
<td>Number of participants limited to 25. Priority for Science, Technology, and Policy MSc and PhD students.</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course teaches the basics of public opinion surveys. We start with the theoretical foundations of the formation of (public) opinion formation and ideology, then turn to the practical lessons of developing and implementing own surveys with a focus on causal inference via survey experiments. Finally, we give practical insights into the analysis of (complex) survey data.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>The goals of this class are:</td>
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<td>- to understand the basics of public opinion research</td>
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<td>- to translate this theoretical knowledge into the practical design and implementation of surveys</td>
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<td>- to make use of survey experiments for causal inference</td>
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<td>At the end of the course, students should be able to use and evaluate public opinion data and design survey experiments to test policy-relevant questions.</td>
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<tr>
<td>860-0003-00L</td>
<td>Cornerstone Science, Technology, and Policy</td>
<td>O</td>
<td>2</td>
<td>1S</td>
<td>T. Bernauer</td>
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<td></td>
<td>ISTP-PhD students please register via the Study Administration</td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>This course introduces students to the MSc STP programme. It provides a general introduction to the study of STP.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>This course introduces students to the MSc program in two ways. First, it provides a general introduction to the study of STP. Second, it exposes students to various complex policy problems and ways and means of coming up with proposals for and assessments of policy options.</td>
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<td>In a reading workshop, students will learn how to improve their skills in reading and understanding scientific papers in English.</td>
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<td></td>
<td>- Introduction to Science, Technology and Policy</td>
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<td>- Reading Workshop: Reading and understanding scientific papers in English.</td>
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<td>A detailed programme will be sent out to the participants in advance to the course.</td>
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<td><strong>Literature</strong></td>
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<td>Literature and references will be available on Moodle.</td>
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<td>860-0004-00L</td>
<td>Bridging Science, Technology, and Policy</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>T. Bernauer, T. Schmidt</td>
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<td></td>
<td>Only for Science, Technology, and Policy MSc and PhD. ISTP-PhD students please register via the Study Administration.</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td></td>
<td>This course first offers a broad conceptual and historical perspective on technological and scientific innovation, and then focuses on different modes of policy analysis and their application to policy questions in a variety of areas.</td>
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<td>This course picks up on the ISTP Cornerstone course in Science, Technology and Policy and goes into greater depth on issues covered in that course, as well as additional issues where science and technology are among the causes of societal challenges but can also help in finding solutions.</td>
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<td><strong>Lecture notes</strong></td>
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<td>Course materials will be made available via Moodle.</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>The course is open to the ISTP's MSc students and to ISTP doctoral students.</td>
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<tr>
<td>860-0005-00L</td>
<td>Colloquium Science, Technology, and Policy (HS)</td>
<td>O</td>
<td>1</td>
<td>2K</td>
<td>T. Bernauer</td>
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<td>Only for Science, Technology, and Policy MSc and PhD. ISTP-PhD students please register via the Study Administration.</td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>Presentations by invited guest speakers from academia and practice/policy. Students are assigned to play a leading role in the discussion and write a report on the respective event.</td>
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<td><strong>Objective</strong></td>
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<td>Presentations by invited guest speakers from academia and practice/policy. Students are assigned to play a leading role in the discussion and write a report on the respective event.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>See the program on the ISTP website: <a href="http://www.istp.ethz.ch/events/colloquium.html">http://www.istp.ethz.ch/events/colloquium.html</a></td>
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<td>The series is open to the public. The lectures start 12:30 and last about 30 minutes followed by an open discussion.</td>
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<td>open to anyone from ETH</td>
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<td>860-0031-00L</td>
<td>Policy Analysis</td>
<td>O</td>
<td>4</td>
<td>2V</td>
<td>B. Steffen, F. M. Egli, T. Schmidt</td>
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<td></td>
<td>Only for Science, Technology, and Policy MSc.</td>
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<td></td>
<td><strong>Abstract</strong></td>
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<td>The course Policy Analysis I will introduce important concepts and methods for ex-ante policy analysis. It will mostly focus on the policy content (vis-à-vis the policy process). We will primarily discuss quantitative methods. The course will contain several practical assignments in which students have to apply the concepts and methods studied.</td>
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<td><strong>Objective</strong></td>
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<td>Students should gain the skill to perform policy analyses independently. To this end, students will be enabled to understand a policy problem and the rationale for policy intervention; to select appropriate impact categories and methods to address a policy problem through policy analysis; to assess policy alternatives, using various ex-ante policy analysis methods; and to communicate the results of the analysis.</td>
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<td></td>
<td><strong>Content</strong></td>
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<td>The course has four major topics:</td>
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<td></td>
<td>• Rationales for public policy in Science and Technology</td>
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<td></td>
<td>• Impact of policies on firms and investors</td>
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<td>• Impacts of policies on socio-technical systems</td>
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<td></td>
<td>• Impact of policies on society at large</td>
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<tr>
<td>363-0503-00L</td>
<td>Principles of Microeconomics</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>M. Filippini</td>
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<tr>
<td></td>
<td>GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.</td>
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<td><strong>Abstract</strong></td>
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<td></td>
<td>The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.</td>
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</table>
The learning objectives of the course are:

(1) Students must be able to discuss basic principles, problems and approaches in microeconomics. (2) Students can analyse and explain simple economic principles in a market using supply and demand graphs. (3) Students can contrast different market structures and describe firm and consumer behaviour. (4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole. (5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics. (6) Students can apply simple mathematical concepts on economic problems.

Topics covered by the course are:

- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book: N. Gregory Mankiw and Mark P. Taylor (2020), "Microeconomics", 5th edition, South-Western Cengage Learning.

The book can also be used for the course 'Principles of Macroeconomics' (Sturm)

Complementary:

The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.

Students will be able to:
1) critically consider biological data books and local, regional, and national inventories;
2) evaluate the validity of ecological criteria used in decision making processes;
3) critically appraise the handling of ecological data and criteria used in the process of evaluation
4) perform an ecological evaluation project from the field survey up to the decision making and planning.

Powerpoint slides are available on the webpage. Additional documents are handed out as copies.

The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group.

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:
- Pflanzen- und Botanik
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbioleogie

Urban Systems and Transportation

This course is an introduction to urban and regional economics. It focuses on the formation and development of urban systems, and highlight how transport infrastructure investments can affect the location, size and composition of such systems.

The main objective of this course is to provide students with some basic tools to analyze the fundamental economic forces at play in urban systems (i.e., agglomeration and congestion forces), and the role of transport networks in shaping the structure of these systems. Why do urban areas grow or decline? How do transport networks affect the location of individuals and firms? Does the location of a firm determine its productivity? Can transport infrastructure investments reduce economic disparities? These are some of the questions that students should be able to answer after having completed the course.

The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and productivity) is unevenly distributed in space. For instance, the share of the population living in urban centers is increasing globally, from 16% in 1900 and 50% in 2000 to about 68% by the year 2050 (UN, World Economic Prospects, 2014). The goal of the first part is then to understand the economic forces at play behind these trends, looking at the effects within and across urban areas. I will also discuss how natural or man-made geographical characteristics (e.g., rivers, mountains, borders, etc.) affect the development of such urban systems.

In the second part, I discuss the planning and pricing of transport networks, moving from simple local models to more complex transport models at a global scale. The key aspects include: the first and second best road pricing, the public provision of transport networks and the demographic effects of transport networks.

In the third part, I combine the previous two parts and analyze the interaction between urban systems and transportation. Thereby, the main focus is to understand the economic mechanisms that can lead to a general equilibrium of all actors involved. However, as the study of the historical development of urban systems and transport networks provides interesting insights, I will discuss how their interaction in the past shapes today’s economic geography.

Finally, I broaden the scope of the course and explore related topics. There will be a particular emphasis on the relation between urban systems and fiscal federalism as well as environmental policies. Both aspects are important determinants of the contemporary developments of urban systems, and as such deserve our attention.

In general, this class focuses on the latest research developments in urban and regional economics, though it does not require prior knowledge in this field. It pays particular attention to economic approaches, which are based on theoretical frameworks with strong micro-foundations and allow for precise policy recommendations.

Lecture notes
Course slides will be made available to students prior to each class.

Literature
Course slides will be made available to students.

Objective
The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively.

There are a large number of efforts around the world to obtain more net benefits from infrastructure assets. This can be seen through the proliferation of codes and guidelines and the increasing amount of research in road infrastructure asset management. Many of these codes and guidelines and much of the research, however, are focused on only part of the large complex problem of infrastructure asset management.

The objective of this course is to provide an overview of the entire infrastructure management process. The high-level process described can be used as a starting point to ensure that infrastructure management is done professionally, efficiently and effectively. It also enables a clear understanding of where computer systems can be used to help automate parts of the process. Students can use this process to help improve the specific infrastructure management processes in the organisations in which they work in the future.

More specifically upon completion of the course, students will

- understand the main tasks of an infrastructure manager and the complexity of these tasks,
- understand the importance of setting goals and constraints in the management of infrastructure,
- be able to predict the deterioration of individual assets using discrete states that are often associated with visual inspections,
- be able to develop and evaluate simple management strategies for individual infrastructure assets,
- be able to develop and evaluate intervention programs that are aligned with their strategies,
- understand the principles of guiding projects and evaluating the success of projects,
- be able to formally model infrastructure management processes, and
- understand the importance of evaluating the infrastructure management process and have a general idea of how to do so.
The weekly lectures are structured as follows:

1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project.

2. Positioning infrastructure management in society. As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator.

3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service.

4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time.

5. Help session 1

6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs.

7. Determining and justifying monitoring – Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time.

8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects.

9. Help session 2

10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management.

11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation.

12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0.

13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process.

14. Help session 3 and submission of project report.

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R. The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.

| Content | 1. Introduction: An introduction to infrastructure management, with emphasis on the consideration of the benefits and costs of infrastructure to all members of society, and balancing the need for prediction accuracy with analysis effort. The expectations of your throughout the semester, including a description of the project. | 2. Positioning infrastructure management in society. As infrastructure plays such an integral part in society, there is considerable need to ensure that infrastructure managers are managing it as best possible. A prominent network regulator explains the role and activities of a network regulator. | 3. Setting goals and constraints – To manage infrastructure you need to know what you expect from it in terms of service and how much you are willing to pay for it. We discuss the measures of service for this purpose, as well as the ideas of quantifiable and non-quantifiable benefits, proxies of service, and valuing service. | 4. Predicting the future – As infrastructure and our expectations of service from it change over time, these changes need to be included in the justification of management activities. This we discuss the connection between provided service and the physical state of the infrastructure and one way to predict their evolution over time. | 5. Help session 1 | 6. Determining and justifying general interventions - It is advantageous to be able to explain why infrastructure assets need to be maintained, and not simply say that they need to be maintained. This requires explanation of the types of interventions that should be executed and how these interventions will achieve the goals. It also requires explaining which interventions are to be done if it is not possible to do everything due to for example budget constraints. This week we cover how to determine optimal intervention strategies for individual assets, and how to convert these strategies into network level intervention programs. | 7. Determining and justifying monitoring – Once it is clear how infrastructure might change over time, and the optimal intervention strategies are determined, you need to explain how you are going to know that these states exist. This requires the construction of monitoring strategies for each of asset. This week we focus on how to develop monitoring strategies that ensure interventions are triggered at the right time. | 8. Converting programs to projects / Analysing projects – Once programs are completed and approved, infrastructure managers must create, supervise and analyse projects. This week we focus on this conversion and the supervision and analysis of projects. | 9. Help session 2 | 10. Ensuring good information – Infrastructure management requires consistent and correct information. This is enabled by the development of a good information model. This week we provide an introduction to information models and how they are used in infrastructure management. | 11. Ensuring a well-run organization – How people work together affects how well the infrastructure is managed. This week we focus on the development of the human side of the infrastructure management organisation. | 12. Describing the IM process – Infrastructure management is a process that is followed continually and improved over time. It should be written down clearly. This week we will concentrate on how this can be done using the formal modelling notation BPMN 2.0. | 13. Evaluating the IM process – Infrastructure management processes can always be improved. Good managers acknowledge this, but also have a plan for continual improvement. This week we concentrate on how you can systematically evaluate the infrastructure management process. | 14. Help session 3 and submission of project report. |

The course uses a combination of qualitative and quantitative approaches. The quantitative analysis required in the project requires at least the use of Excel. Some students, however, prefer to use Python or R.
Abstract
In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

Objective
The aims of this course are:
1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.

Content
In this course, the following topics are discussed:
- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

Lecture notes
No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.
Objective
Public transport is a key driver for making our cities more livable, clean and accessible, providing safe, and sustainable travel options for millions of people around the globe. Proper planning of public transport system also ensures that the system is competitive in terms of speed and cost. Public transport is a crucial asset, whose social, economic and environmental benefits extend beyond those who use it regularly; it reduces the amount of cars and road infrastructure in cities; reduces injuries and fatalities associated to car accidents, and gives transport accessibility to very large demographic groups.

Goal of the class is to understand the main characteristics and differences of public transport networks. Their various performance criteria based on various perspective and stakeholders. The most relevant decision making problems in a planning tactical and operational point of view
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate possible improvements to existing networks of public transport and the management of those networks; optimize the use of resources in public transport.

General structure:
general introduction of transport, modes, technologies, system design and line planning for different situations, mathematical models for design and line planning timetabling and tactical planning, and related mathematical approaches operations, and quantitative support to operational problems, evaluation of public transport systems.

Content
Basics for line transport systems and networks Passenger/Supply requirements for line operations Objectives of system and network planning, from different perspectives and users, design dilemmas Conceptual concepts for passenger transport: long-distance, urban transport, regional, local transport Planning process, from demand evaluation to line planning to timetables to operations Matching demand and modes Line planning techniques Timetabling principles Allocation of resources Management of operations Measures of realized operations Improvements of existing services

Lecture notes
Lecture slides are provided.

Literature
Ceder, Avi: Public Transit Planning and Operation, CRC Press, 2015, ISBN 978-1466563919 (English)

Fostered competencies
Subject-specific Competencies Concepts and Theories assessed Techniques and Technologies assessed
Method-specific Competencies Analytical Competencies assessed Decision-making assessed Media and Digital Technologies not assessed Problem-solving assessed Project Management not assessed
Social Competencies Communication assessed Cooperation and Teamwork assessed Customer Orientation assessed Leadership and Responsibility not assessed Self-presentation and Social Influence not assessed Sensitivity to Diversity not assessed Negotiation not assessed
Personal Competencies Adaptability and Flexibility not assessed Creative Thinking assessed Critical Thinking assessed Integrity and Work Ethics not assessed Self-awareness and Self-reflection not assessed Self-direction and Self-management not assessed

103-0317-00L Spatial Planning and Development W 3 credits 2G D. Kaufmann, A. Kuitenbrouwer
Only for master students, otherwise a special permission by the lecturer is required.

Abstract
The course deals with important theoretical, material and methodical foundations for action and decision-making of spatial relevance. This course discusses central tasks and possible solutions for current and future challenges of spatial development in Switzerland and Europe.
Spatial development deals with the development, formation and arrangement of our environment. In order to be able to mediate between the different demands, interests and projects of multiple actors, a forward-looking, action-oriented and robust planning is necessary. It is committed - in the sense of a sustainable spatial development - to the economical handling of resources, in particular of the non-replicable resource soil.

The lecture introduces necessary basic knowledge and is based on the following main topics:

- Inward development and challenges of spatial transformation
- Planning approaches and The (political) steering of spatial development
- Interplay of formal and informal processes and processes across different scales of spatial development
- Methods of action-oriented planning in situations of insecurity
- Integrated space and infrastructure development
- Different types of participation in spatial development

By taking up the lecture, the students are able to recognize cross-scale, complex tasks of spatial development and transformation and to use their theoretical, methodical and professional knowledge to clarify them.

Content

- Planning approaches and political organization in Switzerland
- Tasks of spatial relevance
- Key figures and ratios
- Drivers of spatial development
- Steering spatial development I: Policy
- Steering spatial development II: Formal and informal instruments
- Organizing spatial development I: Governance
- Organizing spatial development II: Processes and organization
- Methods in spatial planning I
- Methods in spatial planning II
- Planning in complex situations
- Participation in spatial development
- Present and future core tasks of spatial development

Lecture notes

Further information and the documents for the lecture can be found on Moodle:

https://moodle-app2.let.ethz.ch/course/view.php?id=18389

Fostered competencies

Subject-specific Competencies

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies

- Cooperation and Teamwork: not assessed

Personal Competencies

- Creative Thinking: assessed
- Critical Thinking: assessed
- Self-direction and Self-management: not assessed

052-0707-00L Urban Design III

W 2 credits 2V H. Klumpner, M. Fessel

Autumn Semester 2022

Objective

How can students of architecture become active agents of change? What does it take to go beyond a building’s scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.

Content

Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection.

The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically reflect upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.
The objective of this course is to introduce the students to the fundamentals, technologies, modern day application, and economics of wind energy. This mechanical engineering course focuses on the technical aspects of wind turbines; non-technical issues are not within the scope of this technically oriented course. On completion of this course, the student shall be able to conduct the preliminary aerodynamic and structural design of the wind turbine blades. The student shall also be more aware of the broad context of drivetrains, dynamics and control, electrical systems, and meteorology, relevant to all types of wind turbines.

### Energy and Mobility

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0252-08L</td>
<td>Evidence-Based Design: Methods and Tools for Evaluating Architectural Design</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>M. Gath Morad, C. Hölscher, L. Narvae Zertuche, C. Veddeler</td>
</tr>
</tbody>
</table>

**Abstract**

Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailor for architecture design students.

**Objective**

The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

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**Course Moodle:** https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

**Prerequisites / notice:** 1 excursion per semester, 2 case studies, guest speakers for specific topics.

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<tr>
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<th>Hours</th>
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</tr>
</thead>
<tbody>
<tr>
<td>227-0731-00L</td>
<td>Power Market I - Portfolio and Risk Management</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>D. Reichelt, G. A. Koeppe</td>
</tr>
</tbody>
</table>

**Abstract**

Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

**Objective**


**Content**

1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions

3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m²m, VaR, hpf, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2
   2.8. Risk Management 3 (enterprise wide)

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hybrid power
   4.6. Incentive regulation

---

**Course Moodle:** https://moodle-app2.let.ethz.ch/enrol/index.php?id=11636

**Prerequisites / notice:** 1 excursion per semester, 2 case studies, guest speakers for specific topics.
I. Karlin

Nuclear Energy Conversion

Lecture slides and supplementary documentation will be available online.

Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic

This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding

2V+1U

A. Manera

Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course

Hand-outs will be distributed. Additional literature and information on the website of the lab:

1. Course slides will be made available to students prior to each class.


The course is organized in four parts. I start with the key observation that economic activity (both in terms of population density and

Prerequisites / Content

<table>
<thead>
<tr>
<th>Prerequisites</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculus, physics, and engineering mechanics</td>
<td>Nuclear fundamentals of the fission reaction and the sustainable chain reaction, thermal design, construction, function and operation of nuclear reactors and power plants, light water reactors and other reactor types, core design and control.</td>
</tr>
</tbody>
</table>

Literature

<table>
<thead>
<tr>
<th>Literature</th>
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<tbody>
<tr>
<td>Course slides will be made available to students prior to each class.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>151-0163-00L Nuclear Energy Conversion</th>
<th>W 4 credits 2V+1U A. Manera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>Students get an overview on energy conversion in nuclear power plants, on construction and function of the most important types of nuclear reactors with special emphasis to light water reactors. They obtain the mathematical/physical basis for quantitative assessments concerning most relevant aspects of design, dynamic behaviour as well as material and energy flows.</td>
</tr>
</tbody>
</table>

| **Objective** | Nuclear physics of fission and chain reaction. Thermodynamics of nuclear reactors. Design of the reactor core. Introduction into the dynamic behaviour of nuclear reactors. Overview on types of nuclear reactors, difference between thermal reactors and fast breeders. Construction and operation of nuclear power plants with pressurized and boiling water reactors, role and function of the most important safety systems, special features of the energy conversion. Development tendencies of reactor technology. |

| **Content** | Hand-outs will be distributed. Additional literature and information on the website of the lab: https://www.ethz.ch/content/specialinterest/mavt/energy-technology/lab-of-nuclear-energy-systems/en/studium/teaching-materials/151-0163-00l-nuclear-energy-conversion.html |


<table>
<thead>
<tr>
<th>151-1633-00L Energy Conversion</th>
<th>W 4 credits 3G I. Karlin, G. Sansavini</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract</strong></td>
<td>This course provides the students with an introduction to thermodynamics and energy conversion. Students shall gain basic understanding of energy and energy interactions as well as their link to energy conversion technologies.</td>
</tr>
</tbody>
</table>

| **Objective** | Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes; Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to build up students' intuition about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibrium. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included. |

| **Content** | This course is intended for students outside of D-MAVT. |

| **Literature** | Thermodynamics: An Engineering Approach, by Cengel, Y. A. and Boles, M. A., McGraw Hill |

| **Prerequisites / notice** | Students are assumed to have an adequate background in calculus, physics, and engineering mechanics. |
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

151-0567-00L Engine Systems

Abstract
Introduction to current and future engine systems and their control systems

Objective
Introduction to methods of control and optimization of dynamic systems. Application to real engines. Understand the structure and behavior of drive train systems and their quantitative descriptions.

Content
Physical description and mathematical models of components and subsystems (mixture formation, load control, supercharging, emissions, drive train components, etc.).
Case studies of model-based optimal design and control of engine systems with the goal of minimizing fuel consumption and emissions.

Lecture notes
Introduction to Modeling and Control of Internal Combustion Engine Systems
Guzzella Lino, Onder Christopher H.
ISBN: 978-3-642-10774-0

Prerequisites / notice
Combined homework and testbench exercise (air-to-fuel-ratio control or idle-speed control) in groups

227-0122-00L Introduction to Electric Power Transmission: System & Technology

Abstract
Introduction to theory and technology of electric power transmission systems.

Objective
At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of transformers and lines, calculate stationary power flows and other basic parameters in simple power systems.

Content
Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems.

Lecture notes
Lecture script in English, exercises and sample solutions.

227-0665-00L Battery Integration Engineering

Does not take place this semester.
Priority given to Electrical and Mechanical Engineering students

Students are required to have attended one of the following courses:
- 227-0664-00L Technology and Policy of Electrical Energy Storage
- 529-0440-00L Physical Electrochemistry and Electrocatalysis
- 529-0191-01L Renewable Energy Technologies II, Energy Storage and Conversion
- 529-0659-00L Electrochemistry
Abstract
Batteries enable sustainable mobility, renewable power integration, various power grid services, and residential energy storage. Linked with low cost PV, Li-ion batteries are positioned to shift the 19th-century centralized power grid into a 21st-century distributed one. As with battery integration, this course combines understanding of electrochemistry, heat & mass transfer, device engineering.

Objective
The learning objectives are:
- Apply critical thinking on advancements in battery integration engineering. Assessment reflects this objective and is based on review of a scientific paper, with mark weighting of 10 / 25 / 65 for a proposal / oral presentation / final report, respectively.
- Design battery system concepts for various applications in the modern power system and sustainable mobility, with a deep focus on replacing diesel buses with electric buses combined with charging infrastructure.
- Critically assess progresses in battery integration engineering: from material science of novel battery technologies to battery system design.
- Apply “lessons learned” from the history of batteries to assess progress in battery technology.
- Apply experimental and physical concepts to develop battery models in order to predict lifetime.
- Battery systems for the modern power grid and sustainable mobility.
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.
- Sustainability and life cycle analysis of battery system innovations.

Content
- Battery systems for the modern power grid and sustainable mobility.
- Battery lifetime modeling by aging, thermal, and electric sub-models.
- Electrical architecture of battery energy storage systems.
- History and review of electrochemistry & batteries, and metrics to assess future developments in electrochemical energy storage.
- Sustainability and life cycle analysis of battery system innovations.

Prerequisites / notice
Limited to 30 Students. Priority given to Electrical and Mechanical Engineering students.

Exception given for PhD students

Data and Computer Science

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>263-3210-00L</td>
<td>Deep Learning</td>
<td>W</td>
<td>8 credits</td>
<td>3V+2U+2A</td>
<td>T. Hofmann, F. Perez Cruz, N. Perraudin</td>
</tr>
</tbody>
</table>

Abstract
Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

Objective
In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.

Prerequisites / notice
This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustive list below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://ias.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://l2.inf.ethz.ch/teaching/pai-f18

252-1414-00L | System Security                                      | W    | 7 credits | 2V+2U+2A     | S. Capkun, S. Shinde |

Abstract
The first part of the course covers general security concepts and hardware-based support for security. In the second part, the focus is on system design and methodologies for building secure systems.

Objective
In this lecture, students learn about the security requirements and capabilities that are expected from modern hardware, operating systems, and other software environments. An overview of available technologies, algorithms and standards is given, with which these requirements can be met.
The first part of the lecture covers hardware-based security concepts. Topics include the concept of physical and software-based side channel attacks on hardware resources, architectural support for security (e.g., memory management and permissions, disk encryption), and trusted execution environments (Intel SGX, ARM TrustZone, AMD SEV, and RISC-V Keystone).

In the second part, the focus is on system design and methodologies for building secure systems. Topics include: common software faults (e.g., buffer overflows, etc.), bug-detection, writing secure software (design, architecture, QA, testing), compiler-supported security (e.g., control-flow integrity), and language-supported security (e.g., memory safety).

Along the lectures, model cases will be elaborated and evaluated in the exercises.

**263-4640-00L Network Security**

**Abstract**
Some of today's most damaging attacks on computer systems involve exploitation of network infrastructure, either as the target of attack or as a vehicle to attack end systems. This course provides an in-depth study of network attack techniques and methods to defend against them.

**Objective**
- Students are familiar with fundamental network-security concepts.
- Students can assess current threats that Internet services and networked devices face, and can evaluate appropriate countermeasures.
- Students can identify and assess vulnerabilities in software systems and network protocols.
- Students have an in-depth understanding of a range of important state-of-the-art security technologies.
- Students can implement network-security protocols based on cryptographic libraries.

**Content**
The course will cover topics spanning four broad themes with a focus on the first two themes:
1. network defense mechanisms such as public-key infrastructures, TLS, VPNs, anonymous-communication systems, secure routing protocols, secure DNS systems, and network intrusion-detection systems;
2. network attacks such as hijacking, spoofing, denial-of-service (DoS), and distributed denial-of-service (DDoS) attacks;
3. analysis and inference topics such as traffic monitoring and network forensics; and
4. new technologies related to next-generation networks.

In addition, several guest lectures will provide in-depth insights into specific current real-world network-security topics.

**Prerequisites / notice**
This lecture is intended for students with an interest in securing Internet communication services and network devices. Students are assumed to have knowledge in networking as taught in a communication networks lecture like 252-0064-00L or 227-0120-00L. Basic knowledge of information security or applied cryptography as taught in 252-0211-00L or 263-4660-00L is beneficial, but an overview of the most important cryptographic primitives will be provided at the beginning of the course.

The course will involve several graded course projects. Students are expected to be familiar with a general-purpose or network programming language such as C/C++, Go, Python, or Rust.

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**252-0535-00L Advanced Machine Learning**

**Abstract**
Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

**Objective**
Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.
The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

**Fundamentals:**
- What is data?
- Bayesian Learning
- Computational learning theory

**Supervised learning:**
- Ensembles: Bagging and Boosting
- Max Margin methods
- Neural networks

**Unsupervised learning:**
- Dimensionality reduction techniques
- Clustering
- Mixture Models
- Non-parametric density estimation
- Learning Dynamical Systems

Lecture notes
- No lecture notes, but slides will be made available on the course webpage.

Literature

Prerequisites / notice
- The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments.
- Students should have followed at least “Introduction to Machine Learning” or an equivalent course offered by another institution.
- PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

**263-2400-00L**
**Reliable and Trustworthy Artificial Intelligence**

**Abstract**
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

**Objective**
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

**Content**
- Robustness in Deep Learning
  - Adversarial attacks and defenses on deep learning models.
  - Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
  - Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

- Privacy of Machine Learning
  - Threat models (e.g., stealing data, poisoning, membership inference, etc.).
  - Attacking federated machine learning (across modalities such as vision, natural language and tabular).
  - Differential privacy for defending machine learning.
  - Enforcing regulations with guarantees (e.g., via provable data minimization).

- Fairness of Machine Learning
  - Introduction to fairness (motivation, definitions).
  - Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
  - Enforcing group fairness with guarantees.


**Prerequisites / notice**
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in “Intro to ML” classes at most institutions (e.g., “Introduction to Machine Learning” at ETH).

**Fostered competencies**
For solving assignments, some programming experience in Python is expected.

**263-3845-00L**
**Data Management Systems**

**Abstract**
Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2078 of 2416
Abstract

The course will cover the implementation aspects of data management systems using relational database engines as a starting point to cover the basic concepts of efficient data processing and then expanding those concepts to modern implementations in data centers and the cloud.

Objective

The goal of the course is to convey the fundamental aspects of efficient data management from a systems implementation perspective: storage, access, organization, indexing, consistency, concurrency, transactions, distribution, query compilation vs interpretation, data representations, etc. Using conventional relational engines as a starting point, the course will aim at providing an in-depth coverage of the latest technologies used in data centers and the cloud to implement large scale data processing in various forms.

Content

The course will first cover fundamental concepts in data management: storage, locality, query optimization, declarative interfaces, concurrency control and recovery, buffer managers, management of the memory hierarchy, presenting them in a system independent manner. The course will place an special emphasis on understanding these basic principles as they are key to understanding what problems existing systems try to address. It will then proceed to explore their implementation in modern relational engines supporting SQL to then expand the range of systems used in the cloud: key value stores, geo-replication, query as a service, serverless, large scale analytics engines, etc.

Literature

The main source of information for the course will be articles and research papers describing the architecture of the systems discussed. The list of papers will be provided at the beginning of the course.

Prerequisites / notice

The course requires to have completed the Data Modeling and Data Bases course at the Bachelor level as it assumes knowledge of databases and SQL.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>Techniques and Technologies</th>
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<tr>
<td>assessed</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>263-5902-00L</td>
<td>Computer Vision</td>
<td>W</td>
<td>8 credits</td>
<td>3V+1U+3A</td>
<td>M. Pollefeys, S. Tang, F. Yu</td>
</tr>
<tr>
<td>Abstract</td>
<td>The goal of this course is to provide students with a good understanding of computer vision and image analysis techniques. The main concepts and techniques will be studied in depth and practical algorithms and approaches will be discussed and explored through the exercises.</td>
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</table>

Objective

The objectives of this course are:
1. To introduce the fundamental problems of computer vision.
2. To introduce the main concepts and techniques used to solve those.
3. To enable participants to implement solutions for reasonably complex problems.
4. To enable participants to make sense of the computer vision literature.

Content

Camera models and calibration, invariant features, Multiple-view geometry, Model fitting, Stereo Matching, Segmentation, 2D Shape matching, Shape from Silhouettes, Optical flow, Structure from motion, Tracking, Object recognition, Object category recognition

Prerequisites / notice

It is recommended that students have taken the Visual Computing lecture or a similar course introducing basic image processing concepts before taking this course.

252-3005-00L | Natural Language Processing | W    | 7 credits | 3V+3U+1A | R. Cotterell |
| Number of participants limited to 400. |
| Abstract | This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems. |

Objective

The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content

This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature

Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

Life Science and Health

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>376-0021-00L</td>
<td>Materials and Mechanics in Medicine</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>M. Zenobi-Wong, J. G. Snedeker</td>
</tr>
<tr>
<td>Abstract</td>
<td>Understanding of physical and technical principles in biomechanics, biomaterials, and tissue engineering as well as a historical perspective. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.</td>
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</table>

Objective

Understanding of physical and technical principles in biomechanics, biomaterials, tissue engineering. Mathematical description and problem solving. Knowledge of biomedical engineering applications in research and clinical practice.

Content

Biomaterials, Tissue Engineering, Tissue Biomechanics, Implants.

Lecture notes

course website on Moodle

Literature


376-1103-00L | Frontiers in Nanotechnology               | W    | 4 credits | 4V    | V. Vogel, further lecturers |
| Abstract | Many disciplines are meeting at the nanoscale, from physics, chemistry to engineering, from the life sciences to medicine. The course will prepare students to communicate more effectively across disciplinary boundaries, and will provide them with deep insights into the various frontiers. |

Objective

Building upon advanced technologies to create, visualize, analyze and manipulate nano-structures, as well as to probe their nano-chemistry, nano-mechanics and other properties within manufactured and living systems, many exciting discoveries are currently made. They change the way we do science and result in so many new technologies.

The goal of the course is to give Master and Graduate students from all interested departments an overview of what nanotechnology is all about, from analytical techniques to nanosystems, from physics to biology. Students will start to appreciate the extent to which scientific communities are meeting at the nanoscale. They will learn about the specific challenges and what is currently sizzling in the respective fields, and learn the vocabulary that is necessary to communicate effectively across departmental boundaries.

Each lecturer will first give an overview of the state-of-the art in his/her field, and then describe the research highlights in his/her own research group. While preparing their Final Projects and discussing them in front of the class, the students will deepen their understanding of how to apply a range of new technologies to solve specific scientific problems and technical challenges. Exposure to the different frontiers will also improve their ability to conduct effective nanoscale research, recognize the broader significance of their work and to start collaborations.

Content

Starting with the fabrication and analysis of nanoparticles and nanostructured materials that enable a variety of scientific and technical applications, we will transition to discussing biological nanosystems, how they work and what bioinspired engineering principles can be derived, to finally discussing biomedical applications and potential health risk issues. Scientific aspects as well as the many of the emerging technologies will be covered that start impacting so many aspects of our lives. This includes new phenomena in physics, advanced materials, novel technologies and new methods to address major medical challenges.
The course covers the following topics:
1. Introduction into molecular characteristics of molecules involved in the materials-to-biology interface. Molecular design of biomaterials.
2. The concept of biocompatibility.
3. Introduction into methodology used in biomaterials research and application.
4. Introduction to different material classes in use for medical applications.

Content
Introduction into natural and polymeric biomaterials used for medical applications. The concepts of biocompatibility, biodegradation and the consequences of degradation products are discussed on the molecular level. Different classes of materials with respect to potential applications in tissue engineering, drug delivery and for medical devices are introduced. Strong focus lies on the molecular interactions between materials having very different bulk and/or surface chemistry with living cells, tissues and organs. In particular the interface between the materials surfaces and the eukaryotic cell surface and possible reactions of the cells with an implant material are elucidated. Techniques to design, produce and characterize materials in vitro as well as in vivo analysis of implanted and explanted materials are discussed.

A link between academic research and industrial entrepreneurship is demonstrated by external guest speakers, who present their current research topics.

Lecture notes
Handouts are deposited online (moodle).

Literature
- Comprehensive Biomaterials, Ducheyne P. et al., 1st Edition, 2011 (available online via ETH library)

Handouts and references therein.

752-6105-00L Epidemiology and Prevention

Abstract
The module Epidemiology and prevention describes the process of scientific discovery from the detection of a disease and its causes, to the development and evaluation of preventive and treatment interventions and to improved population health.

Objective
The overall goal of the course is to introduce students to epidemiological thinking and methods, which are critical pillars for medical and public health research. Students will also become aware on how epidemiological facts are used in prevention, practice and politics.

Content
The module Epidemiology and prevention, follows an overall framework that describes the course of scientific discovery from the detection of a disease to the development of prevention and treatment interventions and their evaluation in clinical trials and real world settings. We will discuss study designs in the context of existing knowledge and the type of evidence needed to advance knowledge. Examples from nutrition, chronic and infectious diseases will be used in order to show the underlying concepts and methods.

Fostered competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Analytical Competencies
  - Decision-making
  - Problem-solving
  - Project Management
- Method-specific Competencies
- Social Competencies
  - Communication
- Personal Competencies
  - Creative Thinking
  - Critical Thinking

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2080 of 2416
On completion of this course students will be able to demonstrate:

- To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

- The aims of this course are:
  1. To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
  2. To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
  3. To show the importance of ecosystem services.
  4. To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
  5. To identify and measure the characteristics of landscape.
  6. Learn how to use spatial data in landscape planning.

- To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
- To identify and measure the characteristics of landscape.

- Handouts are provided to students in the classroom.

- Subject-specific Competencies

- Concepts and Theories

- Analytical Competencies

- Decision-making

636-0109-00L Stem Cells: Biology and Therapeutic Manipulation

W  4 credits  3G  T. Schroeder

Abstract

Stem cells are central in tissue regeneration and repair, and hold great potential for therapy. We will discuss the role of stem cells in health and disease, and possibilities to manipulate their behavior for therapeutic application. Basic molecular and cell biology, engineering and novel technologies relevant for stem cell research and therapy will be discussed.

Objective

Understanding of current knowledge, and lack thereof, in stem cell biology, regenerative medicine and required technologies. Theoretical preparation for practical laboratory experimentation with stem cells.

Content

We will use different diseases to discuss how to potentially model, diagnose or heal them by stem cell based therapies. This will be used as a guiding framework to discuss relevant concepts and technologies in cell and molecular biology, engineering, imaging, bioinformatics, tissue engineering, that are required to manipulate stem cells for therapeutic application.

Topics will include:

- Embryonic and adult stem cells and their niches
- Induced stem cells by directed reprogramming
- Relevant basic cell biology and developmental biology
- Relevant molecular biology
- Cell culture systems
- Cell fates and their molecular control by transcription factors and signalling pathways
- Cell reprogramming
- Disease modelling
- Tissue engineering
- Bioimaging, Bioinformatics
- Single cell technologies

376-0225-00L Physical Activities and Health

W  3 credits  2V  R. Koels, E. de Bruin, further speakers

Abstract

This course introduces/explores the complex relationship between physical activity, sedentary behavior and health. It will discuss the evolution of current physical activity recommendations. It will examine the current evidence base that has informed physical activity recommendations and that identified physical activity as a key modifiable lifestyle behavior contributing to disease and mortality.

Objective

On completion of this course students will be able to demonstrate:

1. knowledge of and critical awareness of the role of physical activity and sedentary behavior in the maintenance of health and the aetiology, prevention and treatment of disease.
2. thorough knowledge and critical awareness of current recommendations for physical activity, and current prevalence and trends of physical activity and associated diseases
3. awareness of current national and international physical activity policies and how these impact on global challenges

Content

Introduction to Physical Activity for Health, including sedentary behavior

Physical activity epidemiology; concepts principles and approaches

Physical activity and all cause morbidity and mortality

Physical activity and chronic disease; Coronary heart disease, diabetes, bone health, cancer and obesity

Physical activity and brain health

Physical activity and sedentary behavior recommendations

Population prevalence of physical activity and sedentary behavior

Physical activity policies

Physical activity assessment

Literature


Selective journal articles from relevant journals such as Journal of Physical Activity and Health and Journal of Aging and Physical Activity

Prerequisites / notice

From the BSc-course the following book is recommended: ‘Essentials of strength training and conditioning’ T. Baechle, R. Earle (3rd Edition)

Resources and Environment

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0347-00L</td>
<td>Landscape Planning and Environmental Systems</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Grét-Regamey</td>
</tr>
</tbody>
</table>

Abstract

In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

Objective

The aims of this course are:

1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3) To show the importance of ecosystem services.
4) To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5) To identify and measure the characteristics of landscape.
6) Learn how to use spatial data in landscape planning.
### Climate History and Palaeoclimatology

**Abstract**

Climate history and palaeoclimatology explores how the major features of the Earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the Earth's CO₂ concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

**Objective**

The student will be able to describe the natural factors that lead to variations in the Earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

**Content**

The course spans 5 thematic modules:

1. Cyclic variation in the Earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the Earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the Earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the size and stability or fragility of the large polar ice caps and is their evidence that they have dynamic behavior? What are the feedbacks on climate cycles from CO₂ and methane? What drives CO₂ and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?
2. Atmospheric circulation and variations in the Earth's hydrological cycle - How variable are the Earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?
3. Atmospheric circulation and variations in the Earth's hydrological cycle - How variable are the Earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?
4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?
5. How sensitive is Earth's long term climate to CO₂ and cloud feedbacks? What regulates atmospheric CO₂ over long tectonic timescales of millions to tens of millions of years?

The weekly two-hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new palaeoclimatic record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

### Quantitative Vegetation Dynamics: Models from Tree to Globe

**Abstract**

The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

**Objective**

Students will:

- be enabled to understand, assess and evaluate the fundamental properties of dynamic systems using vegetation models as case studies
- obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level
- understand the basic assumptions of the various model types, which dictate the applicability and limitations of the respective model
- be enabled to work with such model types on their own
- appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.
Content

- Models of individuals
  - Deriving single-plant models from inventory measurements
  - Plant models based on 'first principles'

- Models at the stand scale
  - Simple approaches: matrix models
  - Competition for light and other resources as central mechanisms
  - Individual-based stand models: distance-dependent and distance-independent
  - Theoretical models

- Models at the landscape scale
  - Simple approaches: cellular automata
  - Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
  - Landscape models

- Global models
  - Sacrificing local detail to attain global coverage: processes and entities
  - Dynamic Global Vegetation Models (DGVMs)
  - DGVMs as components of Earth System Models

Lecture notes

Handouts will be available in the course and for download

Literature

Will be indicated at the beginning of the course

Prerequisites / notice

- Ideally basic experiences in modelling and systems analysis
- Basic knowledge of programming, ideally in R
- Good knowledge of general ecology, ideally of vegetation dynamics and forest systems

701-1346-00L Carbon Mitigation

W 3 credits 2G N. Gruber

Priority is given to the target groups: Bachelor and Master Environmental Sciences and PHD Environmental Sciences until 20.09.2022.
Waiting list will be deleted 30.09.2022.

Abstract

Future climate change can only be kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

Objective

The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

Content

From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Lecture notes

None

Literature

Will be identified based on the chosen topic.

Prerequisites / notice

Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

103-0347-01L Landscape Planning and Environmental Systems (GIS W Exercises)

W 3 credits 2U A. Grêt-Regamey, C. Brouillet, M. Galleguillos Torres, N. Klein

Abstract

The course content of the lecture Landscape Planning and Environmental Systems (103-0347-00 V) will be illustrated in practical GIS exercises (e.g. habitat modelling, land use change, ecosystem services, connectivity).

Objective

- Practical application of theory from the lectures
- Quantitative assessment and evaluation of landscape characteristics
- Learning useful applications of GIS for landscape planning
- Developing landscape planning measures for practical case studies

Content

- Applications of GIS in landscape planning
- Landscape analysis
- Landscape structural metrics
- Modelling habitats and land use change
- Calculating urban ecosystem services
- Ecological connectivity

Lecture notes

A script and presentation slides for each exercise will be provided on Moodle.

Literature

Will be named in the lecture.

Prerequisites / notice

Basic GIS skills are strongly recommended.
Analytical Competencies

At the end of the course, students:

- not assessed

- Selected scientific articles and book-chapters

The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces

- not assessed

- Adaptability and Flexibility

The course is structured as follows:

- not assessed

- Adaptable and Flexible

- Theoretical Foundations

- Self-presentation and Social Influence

- Sensitivity to Diversity

- Negotiation

Personal Competencies

- Adaptable and Flexibility

- Creative Thinking

- Critical Thinking

- Integrity and Work Ethics

- Self-awareness and Self-reflection

- Self-direction and Self-management

For complementary reading:

- R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided
during the course.

Lecture notes

- Documentation and supporting material:
  - slides used during the lecture
  - exercise sets and solutions
  - R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

Literature

- For complementary reading:

Prerequisites / notice

- Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in
programming (ideally in R). Some elementary background in atmospheric physics and climatology.

701-1253-00L Analysis of Climate and Weather Data

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>C. Frei</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical foreground of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically. Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis. The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.

Lecture notes

- Documentation and supporting material:
  - slides used during the lecture
  - exercise sets and solutions
  - R-packages with software and example datasets for workshop sessions

All material is made available via the lecture web-page.

Literature

- For complementary reading:

Prerequisites / notice

- Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften (701-0105-00L)). Some experience in
programming (ideally in R). Some elementary background in atmospheric physics and climatology.

701-1551-00L Sustainability Assessment

<table>
<thead>
<tr>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>P. Krütli, D. Nef</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>At the end of the course, students:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>- know core concepts of sustainable development, main features of social justice in the context of sustainability, a selection of methodologies for the assessment of sustainable development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Handouts are provided</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Selected scientific articles and book-chapters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L)</td>
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</tr>
</tbody>
</table>
European Climate Change

**Abstract**
The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:

- observational datasets, observation and detection of climate change;
- underlying physical processes and feedbacks;
- numerical and statistical approaches;
- currently available projections.

**Objective**
At the end of this course, participants should:

- understand the key physical processes shaping climate change in Europe;
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;
- be familiar with relevant observational and modeling data sets;
- be able to tackle simple climate change questions using available data sets.

**Content**
Contents:

- global context
- observational data sets, analysis of climate trends and climate variability in Europe
- global and regional climate modeling
- statistical downscaling
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects
- projections of European and Alpine climate change

**Lecture notes**
Slides and lecture notes will be made available at [http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html](http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html)

**Prerequisites / notice**
Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology.

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Tropical Cropping Systems, Soils and Livelihoods (with Excursion)

**Abstract**
This course guides students in analyzing and comprehending tropical agroecosystems and food systems. Students gain practical knowledge of field methods, diagnostic tools and survey methods for tropical soils and agroecosystems. An integral part of the course is the two-week field project in Ethiopia, which is co-organized with Eldoret University (Kenya) and KU Leuven (Belgium).

**Objective**

(1) Overview of the major land use systems in Tropical agroecosystems in several contexts Africa
(2) Interdisciplinary analysis of agricultural production systems
(3) Knowledge on methods to assess agroecological performance of a tropical agroecosystems
(4) Hands-on training on the use of field methods, diagnostic tools and survey methods.
(5) Gain practical knowledge on how to assess to climate resilience and farming systems.
(6) Collaboration in international students and stakeholders

**Content**
This course guides students in analyzing and comprehending tropical agroecosystems. Students gain theoretical knowledge of field methods, diagnostic tools for tropical soils and agroecosystems. Various experts will present their projects and perspectives on various subjects from Food security, climate mitigation, agroecology, resilience to soil physics or agricultural economics. Students will engage in readings, discussions and exchanges on the specificities of tropical agriculture. On, students gain practical knowledge on field - An integral part of the course is the two-week field project in a Tropical region, meeting several stakeholders of the agricultural and food systems and conducting various assessments related to climate resilience and farming systems.

On the second module, students gain practical knowledge on field - An integral part of the course is the two-week field project in Kenya, conducting various assessments related to Food and Energy Security.

**Prerequisites / notice**
We would require the students enrolled to the class to send a short cover letter (1-page max.) by September 23rd 2022, justifying your motivation to enroll to this class. A selection of 20 students will be done on the basis of the letters.
Abstract  Principles of hydrothermal ore formation, using base metal deposits (Cu, Pb, Zn) in sedimentary basins to explain the interplay of 
geological, chemical and physical factors from global scale to sample scale. Introduction to orthomagmatic ore formation (mostly Cr, Ni, 
PGE). Introduction to supergene residual deposits (Ni, Al).

Objective Understanding the fundamental processes of hydrothermal, magmatic and supergene ore formation, recognising and interpreting 
mineralised rocks in geological context.

Content  (a) Principles of hydrothermal ore formation: base metal deposits in sedimentary basins. Practical classification of sample suites by genetic 
ore deposit types. Mineral solubility and ore deposition, principles & thermodynamic prediction using activity diagrams. Driving forces and structural focussing 
of hydrothermal fluid flow.

(b) Introduction to orthomagmatic ore formation. Chromite, Ni-Cu sulphides and PGE in layered mafic intrusions. Distribution coefficients 
between silicate and sulphide melts. Carbonatites and pegmatite deposits.

(c) Introduction to supergene residual deposits with emphasis on Ni laterites and bauxites.

Lecture notes Notes handed out during lectures.

Literature Extensive literature list distributed in course.

Prerequisites / 
notice  2 contact hours per lecture / week including lectures, exercises and practical study of samples, and small literature-based student 
presentations. Supplementary contact for sample practicals and exercises as required. Credits and mark based on participation in course 
(exercises, 50%) and 1h30 written exam in the last lecture of the semester (50%).

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
<th>Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
<td>not assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td></td>
<td>not assessed</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
<td>not assessed</td>
</tr>
<tr>
<td>Project Management</td>
<td></td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self-presentation and Social Influence</td>
<td></td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sensitivity to Diversity</td>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
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<td></td>
<td></td>
<td>Negotiation</td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<td></td>
<td></td>
<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Case Studies

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>860-0011-00L</td>
<td>Agent-Based Modeling and Social System Simulation - With Coding Project</td>
<td>W</td>
<td>6</td>
<td>2S+2A</td>
<td>N. Antulov-Fantulin, D. Carpentras, D. Helbing</td>
</tr>
</tbody>
</table>

Prerequisites: Good mathematical skills, basic programming skills, elementary probability and statistics.

Abstract  This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific 
research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are 
expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective  The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific 
problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of 
scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically. The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral 
presentation.

Content  Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex 
networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Lecture notes  The lecture slides will be presented on the course web page after each lecture.
Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Fostered competencies

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

The course provides the necessary knowledge to develop models supporting and also evaluating the solution of given planning problems. The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis.

Examples of such planning problems are the estimation of traffic volumes, prediction of estimated utilization of new public transport lines, and evaluation of effects (e.g. change in emissions of a city) triggered by building new infrastructure and changes to operational regulations.

To cope with that, the problem is divided into sub-problems, which are solved using various statistical models (e.g. regression, discrete choice analysis) and algorithms (e.g. iterative proportional fitting, shortest path algorithms, method of successive averages).

The course is composed of a lecture part, providing the theoretical knowledge, and an applied part in which students develop their own models in order to evaluate a transport project/policy by means of cost-benefit analysis. Interim lab session take place regularly to guide and support students with the applied part of the course.

Moodle platform (enrollment needed)


Students who are enrolled for “Discovering Management Exercises” are asked to write an essay about a particular management issue of assessed B. Clarysse assessed 1U Type Case Study Research Paper in Science, Technology assessed A. Discovering Management, S. Brusoni, assessed assessed Students are able to apply their problem-solving and analytical skills to address a particular societal challenge. assessed 3G assessed ECTS assessed 6A assessed Students following this course should also be enrolled for course 351-0778-00L, “Discovering Management”. They will be asked to write an essay about a particular management issue of choice, using your insights from Discovering Management. Students who are enrolled for “Discovering Management Exercises” are asked to write an essay about a particular management issue of assessed assessed 3 credits assessed 351-0778-01L Discovering Management (Exercises) Complementary exercises for the module Discovering Management. Prerequisite: Participation and successful completion of the module Discovering Management (351-0778-00L) is mandatory. This course is offered complementary to the basis course 351-0778-00L, “Discovering Management”. The course offers an additional exercise. The general objective of Discovering Management (Exercises) is to complement the course “Discovering Management” with one larger additional exercise. Students who are enrolled for “Discovering Management Exercises” are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management. Students have the option to either write this alone or in a group of two students. All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. Students following this course should also be enrolled for course 351-0778-00-01L, “Discovering Management”. Complementary exercises for the module Discovering Management. Entry level course in management for BSc, MSc and PHD students at all levels not belonging to D-MTEC. This course can be complemented with Discovering Management (Exercises) 351-0778-01L. Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC. Students are able to apply their problem-solving and analytical skills to address a particular societal challenge. Students are able to apply their problem-solving and analytical skills to address a particular societal challenge. After successfully completing the companion course and the research paper, the student office will assign both courses to the category case studies.
The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

In particular, the aims of the course are to:
1. broaden understanding of management principles and frameworks
2. advance insights into the sources of corporate and entrepreneurial success
3. develop skills to apply this knowledge to real-life managerial problems

The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

Content
The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.

Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

Lecture notes
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle. These course materials will form the point of departure for the lectures, class discussions and team work.

Fostered competencies
- Subject-specific Competencies
  - Concepts and Theories
  - Method-specific Competencies
  - Analytical Competencies
  - Social Competencies
  - Problem-solving
  - Communication
  - Creative Thinking

Literature
Lecture notes: All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

Prerequisites / notice
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

**865-0008-00L Policy Evaluation and Applied Statistics**

**W 3 credits 2G I. Günther, K. Harttgen, K. Schneider**

**Abstract**

This course introduces students to key methods for quantitative policy impact evaluation and covers the different stages of the research process. Acquired skills are applied in a self-selected project applying experimental methods. Students also learn how to perform simple statistical analyses with the statistical Software R.

**Objective**

- Students
  - know strategies to test causal hypotheses using experimental methods and regression analysis.
  - are able to formulate and implement a research design for a particular policy question and a particular type of data.
  - are able to critically read and assess published studies on policy evaluation.
  - are able to use the statistical software R for data analysis.
  - can apply all the steps involved in a policy impact evaluation.

**Content**

Policy impact evaluation employs a wide variety of research methods, such as statistical analysis of secondary data, surveys or laboratory and field experiments. The course will begin with an overview of the various methodological approaches, including their advantages and disadvantages and the conditions under which their use is appropriate. It will continue with a discussion of the different stages of a policy impact evaluation, including hypothesis generation, formulating a research design, measurement, sampling, data collection and data analysis. For data analysis, linear regression models will be revised, with a focus on difference-in-difference methods, regression discontinuity design and randomized controlled trials used for policy evaluation. Students, who already have a solid background in these methods can skip these sessions.

Throughout the course, students will work on a self-selected project on a suitable topic. In addition, students will have to solve bi-weekly assignments.

**701-1631-00L Foundations of Ecosystem Management**

**W 5 credits 3G J. Ghazoul, A. Giger Dray**

**Priority is given to the target groups until 26.09.2022,**

**Target groups**

- MAS ETH in Raumplanung
- MAS ETH in Sustainable Water Resources
- Science, Technology and Policy MSc
- Environmental Sciences MSc
- Agricultural Sciences MSc

**Waiting list will be deleted on 30.09.2022**

**Abstract**

This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

**Objective**

- Students should be able to
  a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
  b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.
Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental well-being. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

Lecture notes
No Script

Literature

851-0467-00L From Traffic Modeling to Smart Cities and Digital Democracies
W 3 credits 2S D. Helbing, S. Mahajan

Number of participants limited to 40.

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

Objective
To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Literature

Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/281629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future
Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/2020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/686.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective-collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f48e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_fkmr1_1?dchild=1&keywords=coordination+Jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Decentralized Collective Learning for Self-managed Sharing Economies
https://dl.acm.org/doi/abs/10.1145/3277668

Prerequisites / notice

Further literature will be recommended in the lectures.
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
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<tr>
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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
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</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<td>Negotiation</td>
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<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td>Self-direction and Self-management</td>
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851-0585-41L Computational Social Science  W 3 credits  2S  D. Helbing, J. Argota Sánchez-Vaquerizo, M. Korecki

Abstract
The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g. sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

Objective
Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.

Literature
Computational Social Science
https://science.sciencemag.org/content/sci/323/5915/721.full.pdf

Manifesto of Computational Social Science
https://link.springer.com/article/10.1140/epjst/e2012-01697-8

Social Self-Organisation

How simple rules determine pedestrian behaviour and crowd disasters
https://www.pnas.org/content/108/17/6884.short

Peer review and competition in the Art Exhibition Game
https://www.pnas.org/content/113/30/8414.short

Generalized network dismantling
https://www.pnas.org/content/116/14/6554.short

Computational Social Science: Obstacles and Opportunities
https://science.sciencemag.org/content/369/6507/10607/rss%253D1=

Bit by Bit: Social Research in the Digital Age
https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFX2/

Further literature will be recommended in the lectures.

Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
Resource and Environmental Economics

**Abstract**
Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

**Objective**
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

**Content**
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental frameworks that have developed over the last 25 years, and also be able to appraise those frameworks critically.

**Literature**

Climate Policy

**Abstract**
This course provides an in-depth analysis both of the theoretical underpinnings to different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

This course is about all that. The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

There will be daily reading assignments, which we will then discuss critically during the class sessions. All of these will be posted in PDF format on a course Moodle. In addition, there will be two books to be read over the course of the semester. Both of these can be accessed from the ETH library or in PDF form free of charge. They are:


Fostered competencies

<table>
<thead>
<tr>
<th>Focused competencies</th>
<th>Subject-specific Competencies</th>
<th>Methods-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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<tr>
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<td>Decision-making</td>
<td>Problem-solving</td>
<td>Negotiation</td>
<td>Critical Thinking</td>
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052-0707-00L Urban Design III W 2 credits 2V H. Klumpner, M. Fessel

Objective

Students are introduced to a narrative of ‘Urban Stories’ through a series of three tools driven by social, governance, and environmental transformations in today’s urbanization processes. Each lecture explores one city’s spatial and organizational ingenuity born out of a particular place’s realities, allowing students to transfer these inventions into a catalog of conceptual tools.

How can students of architecture become active agents of change? What does it take to go beyond a building’s scale, making design-relevant decisions to the city rather than a single client? How can we design in cities with a lack of land, tax base, risk, and resilience, understanding that Zurich is the exception and these other cities are the rule? How can we discover, set rather than follow trends and understand existing urban phenomena activating them in a design process? The lecture series produces a growing catalog of operational urban tools across the globe, considering Governance, Social, and Environmental realities. Instead of limited binary comparing of cities, we are building a catalog of change, analyzing what design solutions cities have been developing informally incrementally over time, why, and how. We look at the people, institutions, culture behind the design and make concepts behind these tools visible. Students get first-hand information from cities where the chair as a Team has researched, worked, or constructed projects over the last year, allowing competent, practical insight about the people and topics that make these places unique. Students will be able to use and expand an alternative repertoire of experiences and evidence-based design tools, go to the conceptual core of them, and understand how and to what extent they can be relevant in other places. Urban Stories is the basic practice of architecture and urban design. It introduces a repertoire of urban design instruments to the students to use, test, and start their designs.
Urban form cannot be reduced to physical space. Cities result from social construction, under the influence of technologies, ecology, culture, the impact of experts, and accidents. Urban un-concluded processes respond to political interests, economic pressure, cultural inclinations, along with the imagination of architects and urbanists and the informal powers at work in complex adaptive systems. Current urban phenomena are the result of urban evolution. The facts stored in urban environments include contributions from its entire lifecycle, visible in the physical environment, and non-physical aspects. This imaginary city exists along with its potentials and problems and with the conflicts that have evolved. Knowledge and understanding, along with a critical observation of the actions and policies, are necessary to understand the diversity and instability present in the contemporary city and understand how urban form evolved to its current state.

How did cities develop into the cities we live in now? Urban plans, instruments, visions, political decisions, economic reasonings, cultural inputs, and social organization have been used to operate in urban settlements in specific moments of change. We have chosen cities that exemplify how these instruments have been implemented and how they have shaped urban environments. We transcribe these instruments into urban operational tools that we have recognized and collected within existing tested cases in contemporary cities across the globe.

This lecture series will introduce urban knowledge and the way it has introduced urban models and operational modes within different concrete realities, therefore shaping cities. The lecture series translates urban knowledge into operational tools, extracted from cities where they have been tested and become exemplary samples, most relevant for understanding how the urban landscape has taken shape. The tools are clustered in twelve thematic clusters and three tool scales for better comparability and cross-reflection. The Tool case studies are compiled into a global urbanization toolbox, which we use as typological models to read the city and critically react upon it. The presented contents are meant to serve as inspiration for positioning in future professional life and provide instruments for future design decisions.

In an interview with a local designer, we measure our insights against the most pressing design topics in cities today, including inclusion, affordable housing, provision of public spaces, and infrastructure for all.

Lecture notes The learning material, available via https://moodle-app2.let.ethz.ch/ is comprised of:
- Toolbox 'Reader' with an introduction to the lecture course and tool summaries
- Weekly exercise tasks
- Infographics with basic information of each city
- Quiz question for each tool
- Additional reading material
- Interviews with experts
- Archive of lecture recordings
- Reading material will be provided throughout the semester.

860-0026-00L Data Practices W 3 credits 2S M. Leese

Abstract The aim of this course is to establish an understanding of data as embedded in social contexts. Studying data from a social scientific perspective is necessary to account for these influences and analyze the ways in which data practices shape the ways in which data allow us to see and modify the world.

Objective At the end of the term, students will be able to:
- reflect concepts and theories of data practices and situate them within wider social science contexts
- identify key actors, sites, and domain contexts of data practices
- develop analytical tools to study data practices empirically

Content The aim of this course is to establish an understanding of data as embedded in social contexts. Data do not exist independently of the ideas, instruments, contexts and rationales used to generate, process, and analyze them. They are not neutral representations of external realities, but they are imbued with political and economic interests, cultural norms and tacit assumptions. Studying data from a social scientific perspective, it is thus necessary to account for these influences and analyze the ways in which data practices shape the ways in which data allow us to see and modify the world.

851-0589-00L Technology and Innovation for Development W 3 credits 2V P. Aerni

Abstract Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

Objective
- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies. The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different cases and situations when such interventions are designed to regulate or facilitate and how such interventions affect the rate and direction of technological change.

Lecture notes Reader with issue-specific articles. E-version is partly available on Moodle.
Students are expected to implement models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Prerequisites:
Basic programming skills, elementary probability and statistics.

Objectives:
The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

The course will be taught in English. Number of participants limited to 100.

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester. The class will be taught in English. Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

The students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Prerequisites:
Basic programming skills, elementary probability and statistics.

Objectives:
The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

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The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Prerequisites:
Basic programming skills, elementary probability and statistics.

Objectives:
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The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.
The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

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**Prerequisites / notice**

**Fostered competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

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**851-0732-06L Law & Tech**

Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/s/o7dtHXV5/AI9CE) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

**Abstract**

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

**Objective**

The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

**Content**

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

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**860-0012-00L Cooperation and Conflict Over International Water Resources**

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

**Abstract**

This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

**Objective**

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.
Role of international engineering during colonialism

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge

E. Tilley
E. Ash

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be
3G
M. Kalina

Building a Robot Judge: Data Science for Decision-Making

Particularly suitable for students of D-INFK, D-ITET, D-MTEC

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge
decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a
working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand,
techologies force us to think carefully about notions of fairness and justice and how they should be applied.

There are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these
working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a
criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and
implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural
networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make
errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be
introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement
an applied data-science research project.
### Internship

The performance counts as electives.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
<td>860-0600-00L</td>
<td>Internship - Short</td>
<td>W</td>
<td>6 credits</td>
<td></td>
<td>external organisers</td>
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<td></td>
<td>The internship can be started the earliest in the second semester. The internship needs to be approved by the study director. Therefore students need to hand in a short description to the study secretary before they start the internship.</td>
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<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The internship is a voluntary part of the MSc curriculum.</td>
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<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The internship serves to make students familiar with policy analysis in a real world setting, for instance in a government agency, a NGO, a regulatory or public affairs division of a private sector firm, or a consulting firm focused on policy analysis.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
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<td>The short internship corresponds to a workload of 180 hours, to be accomplished within 3 months.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>860-0700-00L</td>
<td>Internship - Long</td>
<td>W</td>
<td>12 credits</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td>The internship can be started the earliest in the second semester. The internship needs to be approved by the study director. Therefore students need to hand in a short description to the study secretary before they start the internship.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The internship is a voluntary part of the MSc curriculum.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The internship serves to make students familiar with policy analysis in a real world setting, for instance in a government agency, a regulatory or public affairs division of a private sector firm, or a consulting firm focused on policy analysis.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>The long internship corresponds to a workload of 360 hours, to be accomplished within 6 months.</td>
</tr>
<tr>
<td></td>
<td>Prerequisites / notice</td>
<td></td>
<td></td>
<td></td>
<td>The internship can be started the earliest in the second semester. The internship needs to be approved by the study director. We ask students to hand in a short description to the study secretary before they start the internship.</td>
</tr>
</tbody>
</table>

### Master's Thesis

Only students who fulfill the following criteria are allowed to begin with their master thesis:

a. successful completion of the bachelor programme;
b. fulfilling of any additional requirements necessary to gain admission to the master programme.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>860-0900-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30 credits</td>
<td>64D</td>
<td>Professors</td>
</tr>
<tr>
<td></td>
<td>Only students who fulfill the following criteria are allowed to begin with their master thesis: a. successful completion of the bachelor programme; b. fulfilling of any additional requirements necessary to gain admission to the master programme.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The thesis should demonstrate the students ability to conduct independent research on the basis of the theoreticel and methodological knowledge acquired during the MSc program.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The thesis should demonstrate the students ability to conduct independent research on the basis of the theoreticel and methodological knowledge acquired during the MSc program.</td>
</tr>
</tbody>
</table>

### Science, Technology, and Policy Master - Key for Type

<table>
<thead>
<tr>
<th>O</th>
<th>Compulsory</th>
<th>E-</th>
<th>Recommended, not eligible for credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
<td></td>
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</tr>
</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
### Educational Science

Courses in the category Educational Science are listed under "Programme: Educational Science for Teaching Diploma and TC".

#### Number Title Type ECTS Hours Lecturers

| 851-0240-15L | Designing Educational Environments in Physical Education (EW2 Sport) | O | 4 credits | 2S | H. Gubelmann, R. Scharpf |

**Abstract**

Students learn principles of teaching beyond classroom and regular PE-Lessons:
- Planning and organizing camps and events
- Teaching the "Erganzungsfach Sport"

As a practical part students design the Outdoor event in EW4 of the following term.

**Prerequisites / notice**

EW2 is compulsory requirement for EW4 Sport

| 851-0240-00L | Human Learning (EW1) | O | 2 credits | 2V | E. Stern |

**Abstract**

This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

**Objective**

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

**Content**

- How to plan events and camps
- To assess curricula critically and to use them properly
- How to combine theoretical and practical issues in the ‘Erganzungsfach’

**Literature**


**Lecture notes**

Foliens werden zur Verfügung gestellt.

| 851-0242-08L | Research Methods in Educational Science | W | 1 credit | 2S | C. M. Thurn, Th. Braas, P. Edelsbrunner |

**Abstract**

Literature from the learning sciences is critically discussed with a focus on research methods.

At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

**Objective**

- Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

| 557-0315-00L | Sports Didactics I | O | 4 credits | 2V | A. Thoma |

**Abstract**

Practical implementation in sports of general didactics, with the planning, implementation and evaluation of topics from all the sports-specific areas of tuition in secondary school Level II.

---

**Subject Didactics in Sport**

Important: You can only enroll in the courses of this category if you have not more than 12 CP left for possible additional requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0315-00L</td>
<td>Sports Didactics I</td>
<td>O</td>
<td>4 credits</td>
<td>2V</td>
<td>A. Thoma</td>
</tr>
</tbody>
</table>

Simultaneous enrollment in Introductory Internship Sports - course 557-0210-00L - is compulsory.
The students:  
- Implement the objectives of general didactics in respect of the different types of sport at school.  
- Master the planning, implementation and evaluation of topics from all the sports-specific areas of tuition.  
- Gain an overview of the preparation necessary for the different requirements placed on a sports teacher at secondary school Level II.  
- Try out different teaching structures, such as the lesson, teaching unit, block periods and extra units in sport in addition to those on the timetable.

Implementation of practical sport into general teacher training with planning, execution and evaluation of the topics from all sport-specific areas of the education at this level in Section II.

During the introductory teaching practice, the students sit in on 3 lessons given by the teacher responsible for their teaching practice, and on 7 lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.

In their mentored work on subject didactics, students put into practice the contents of the subject-didactics lectures and go into these in greater depth. Under supervision, they prepare tuition materials that are conducive to learning and/or analyse and reflect on certain topics from a subject-based and pedagogical angle.

Planning and organization of a longer period of instruction in school.

Students observe 3 and teach 7 lessons, supervised by experienced teachers.

Important: You can only enroll in the courses of this category if you have not more than 12 CP left for possible additional requirements.

### Professional Training in Sport

#### 557-0203-01L Mentored Work Subject Didactics Sport  
**Type** Only for Teaching Diploma Sports.  
**ECTS** 4 credits  
**Prerequisites / notice** abgeschlossene Fachdidaktik I  
**Lecturers** A. Thoma, further lecturers

**Objective** The teaching practice takes in 50 sessions. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

**Abstract** Students use their disciplinary skills and educational knowledge for teaching. They know how to judge topics of their subject and can present them in class. Teaching and classroom management in practice is the main target of this course; students have to find a balance between instruction and self-determined activity of their pupils. Together with their supervisors they learn to assess their tasks and achievements.

**Content** Students apply their theoretical background in practice. By teaching sports lessons they improve their teaching skills and classroom management and learn how to interact with pupils. Together with their supervisor they develop an ability of critical reflection of their tasks.

**Lecture notes** see moodle 00 - Lehrdiplom Sport  

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#### 557-0210-00L Introductory Internship Sports  
**Type** Only for Teaching Diploma Sports.  
**ECTS** 3 credits  
**Prerequisites / notice** Lehrdiplom-Studierende müssen die Fachdidaktik Sport I zusammen mit dem Einführungspraktikum Sport - LE 557-0210-00 - belegen.

**Objective** During the introductory teaching practice, the students sit in on 3 lessons given by the teacher responsible for their teaching practice, and teach 7 lessons themselves. The students are given observation and reflection assignments by the teacher responsible for their teaching practice.

**Abstract** The teaching practice takes place in 50 sessions. The teaching practice lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.

**Lecture notes** see moodle 00 - Lehrdiplom Sport  
|-------------|-----------------------------------------------|
|             | Disler P. Dida-Methodische Modelle in der Ausbildung, Dissertation in 2004, 152  
|             | Loosch E., Allgemeine Bewegungsliebe, Limpert Verlag Wiesbaden 1999  
|             | Roth K. & K. Willemczik, Bewegungswissenschaft, Rowohlt Verlag Reinbek 1999  
|             | Röthig P. Sportwissenschaftliches Lexikon, Schorndorf Verlag 2003  
|             | Röthig P. & s. Grössing (Hrsg.) Bewegungsliebe, Kursbuch 3, Wiesbaden 1990/3  

| Prerequisites / notice | Prerequisites for the Teaching Internship: all ECTS in Teaching Diploma Sports, apart from  
|------------------------|--------------------------------------------------|
|                        | - 3 ECTS Educational Science  
|                        | - 4 ECTS Specialized Courses with Educational Focus  
|                        | - 2 ECTS Examination Lessons  

| 557-0220-00L | Partial Teaching Internship Sport  
|--------------|----------------------------------|
|              | Only for Teaching Diploma Sports.  
|              | 5 credits  
|              | A. Thoma, further lecturers  

| Abstract | The teaching practice takes in 30 Sessions. It lasts 4-6 weeks. It gives students the opportunity to implement the contents of their specialist-subject, educational science and subject-didactics training in the classroom. Students also conduct work assignments in parallel to their teaching practice.  
| Objective | Students use their disciplinary skills and educational knowledge for teaching. They know how to judge topics of their subject and can present them in class. Teaching and classroom management in practice is the main target of this course; students have to find a balance between instruction and self-determined activity of their pupils. Together with their supervisors they learn to assess their tasks and achievements.  
| Content | Students apply their theoretical background in practice. By teaching sports lessons they improve their teaching skills and classroom management and learn how to interact with pupils. Together with their supervisor they develop an ability of critical reflection of their tasks.  
| Prerequisites / notice | Dieses Praktikum kann nur zusammen mit dem Modul Lehr- und Lernort Berufsfachschule 1° (ETH: 851-0237-01/ UZH: 090LB151) im Rahmen der berufspädagogischen Zusatzausbildung der Universität Zürich absolviert werden. Studierende, die nur eine Lehrbefähigung nach Abschluss der übrigen Ausbildung anstreben, belegen das Unterrichtspraktikum Sport (557-0208-00L).  

Voraussetzung für das Unterrichtspraktikum: Alle Leistungen im LD Sport müssen bereits erbracht sein, abgesehen von  
- 3 ECTS EW-Fächer  
- 4 ECTS Fachwissenschaftliche Vertiefung  
- 2 ECTS Prüfungslektionen  

| 557-0215-00L | Professional Exercises  
|--------------|------------------------|
|              | Only for BSc HST and Teaching Diploma Sports.  
|              | 2 credits  
|              | to be announced  

| Abstract | Does not take place this semester. The course will only take place with 12 or more registrations. BSc HST students with a J+S-Coach certificate can take the course from 3rd semester onwards, others from 5th semester onwards. 3rd semester students, please send a copy of your J+S-Coach certificate to the study administration HST (hest@hest.ethz.ch).  
| Objective | Students apply teaching methods they learned in Didactics I and II in practical lessons in the gym hall. They also supervise their fellow students and give feedback.  
| Content | ted  
| Lecture notes | Unterlagen auf Moodle  
| Literature | Kernlehreittel Jugend & Sport  

| 557-0211-01L | Examination Lesson I Sports  
|--------------|------------------------|
|              | Only for Teaching Diploma Sports.  
|              | 1 credit  
|              | A. Thoma, further lecturers  

| Abstract | Simultaneous enrolment in “Examination Lesson II Sports” (557-0211-02L) is compulsory.  
| Objective | In the context of an examination lesson conducted and graded at a high school, the candidates provide evidence of the subject-matter-based and didactic skills they have acquired in the course of their training.  
| Lecture notes | Dokument: Schriftliche Vorbereitung für Prüfungslektionen.  
| Prerequisites / notice | Nach Abschluss der übrigen Ausbildung.  

| 557-0211-02L | Examination Lesson II Sports  
|--------------|------------------------|
|              | Only for Teaching Diploma Sports.  
|              | 1 credit  
|              | A. Thoma, further lecturers  

| Abstract | Simultaneous enrolment in “Examination Lesson I Sports” (557-0211-01L) is compulsory.  

Data: 01.11.2022 12:41  
Autumn Semester 2022  
Page 2103 of 2416

- **History of Sports**
  - **Abstract**
    - Comprehension for development and changes of sports from the ancient world to the presence. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day.
  - **Objective**
  - **Content**
  - **Literature**

- **Sport Pedagogy**
  - **Abstract**
    - The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on "pedagogical-psychological aspects of competence development in the context of a multi-perspective physical education".
  - **Objective**
  - **Content**
    - Development of pedagogical-psychological competences for the optimisation of future teaching activities.
    - Subject area of educational psychology
    - Motivating students in physical education
    - Building self-efficacy and strengthen the self-concept
    - Promoting positive emotions and a positive attitude to anxiety
    - Encouraging self-directed learning
    - Leading classes and promoting cooperation
    - Communicating with students efficiently
    - Reflecting your own expectations critically
    - Handling gender issues sensitively
    - Promoting inclusion / Strengthening social and moral development
    - Dealing with difficult students
    - Evaluating achievements of students
  - **Literature**
    - Primärmaterial.

- **Sport Psychology**
  - **Abstract**
    - This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject.
  - **Objective**
  - **Content**
    - Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students’ expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.
    - Main Topics
      - Introduction to sport psychology
      - Cognitions in sports: mental rehearsal and mental training
      - Emotions and stress
      - Motivation: goal-setting in sports
      - Career and career transition in elite sport
      - Coach-Athlete-Interaction
      - Psychological aspects of sport-injury rehabilitation
      - Group dynamics in sport
  - **Literature**
The lectures set out to:
- present the different dimensions, functions and interrelationships of present-day sport
- provide an introduction to the central theories and models of (sport) sociology
- show how far sport reflects society and how it changes and becomes more differentiated in the process
- take current examples to highlight the sociological view of sport.

Content
Sport and social change: developments and trends
The economy and the media: dependencies, consequences, scandals
Social inequalities and distinctions: gender differences and group behavior
Conflicts and politics: sports organizations, doping, violence

Lecture notes
Selected materials for the lecture are available on the Moodle platform.

Literature

A detailed program with additional references will be delivered at the beginning of the lecture.

Fostered competencies
- Subject-specific Competencies
  Concepts and Theories
  assessed
- Method-specific Competencies
  Analytical Competencies
  assessed
- Social Competencies
  Sensitivity to Diversity
  assessed
- Personal Competencies
  Critical Thinking
  assessed

557-0205-00L Mentored Work Specialised Courses in the Respective O 2 credits 4A Supervisors
Subject with an Educational Focus Sport A

Abstract
Pedagogical application of research projects for schools
Introduction of sports pedagogical oriented research projects. Competency to a youth friendly movement and sports education. Competent ‘pedagogical application’ of research projects in the field of movement and sport. Feed in of scientific findings to school lesson settings.

Objective
The students combine and apply general educational aims with a general and specific background of research projects.
They know different educational concepts of the above mentioned, recognise its strengths and weaknesses and are able to apply concepts appropriate to the situation.
They are interested in the (thought-) processes of education and research in sports in Switzerland.
They use their knowledge of research matters to guide educational thought-processes.
They are interested in processes of research in sports.
They approach the research interest of their pupils with the knowledge of sports psychology, sports sociology, sports pedagogy, and sports history.

Content
Die Studierenden wenden die Bewegungs- und Lernziele des Sportunterrichts aus den kantonalen Lehrplänen im Unterricht an und können diese begründen.
Sie interessieren sich für die Prozesse der Forschung Im Sport
Sie erlernen anhand von Projekttaufgaben die didaktische Anwendung der Sportpsychologie, Sportsoziologie, Sportpädagogik und Sportgeschichte und ziehen daraus Konzequenzen für den situativ-variabel orientierten Unterricht.
Sie setzen ihr Wissenswissen ein, um bei den Lernenden Denkprozessen anzustoßen und zu begleiten.

Lecture notes
Skrift unter: https://moodle-app2.let.ethz.ch/course/view.php?id=117>

Prerequisites / notice
- Auswahl von 2 aus 4 Angeboten:
  a) Motor-Learning im Sport (Fachbereich Sportpsychologie)
  - Vorlesung
  - Praktische Umsetzung von Forschungsprojekten für die Schule
  b) Sport im Spannungsfeld zwischen Ethik und Kommerz (Fachbereich Sportsoziologie)
  - Vorlesung
  - Praktische Umsetzung von Forschungsprojekten für die Schule
  c) Mehrperspektivität im Sportunterricht (Fachbereich Sportpädagogik)
  - Vorlesung
  - Praktische Umsetzung von Forschungsprojekten für die Schule
  d) Historische Entwicklung der Lehr und Lernmodell im Sportunterricht (Fachbereich Sportgeschichte)
  - Vorlesung
  - Praktische Umsetzung von Forschungsprojekten für die Schule
  Alle Wahlfachangebote beinhalten:
  - Sportwissenschaftliche Fachpraxis
  - Praktische Umsetzung der Erkenntnisse für die Schule

Specialized Courses in Respective Subject with Educational Focus II
At least 6 CP's must be obtained in this category.
Further courses must be chosen from the “Sports Practice: In-depth Education”.

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
557-0206-00L | Mentored Work Specialised Courses in the Respective O Subject with an Educational Focus Sport B | Only for Teaching Diploma Sports. | 2 credits | 4A | Supervisors

Prerequisite: Sports Didactics I

Abstract
Refurbishment of research projects dealing with motor competencies in sport and professional scientific content related to this area. Competent “didactical implementation” of research content. The Fachwissenschaftliche Vertiefung II orientates itself to the guiding principles of cognitive, conditional and coordination aspects of movement.

Objective

Content

Prerequisites / notice
Mentorated paper in selected sports disciplines.

see Sport Teaching Diploma, Sport Practical: Major Education

Compulsory Elective Courses
At least 6 CP's must be acquired in this category. Further courses must be chosen from the "Sports Practice: In-depth Education and Specialized Education".

**Sports Practice**

The Teaching Diploma in Sports will only be granted to students holding a Master, Diploma or Licentiate degree in Human Movement Sciences and Sports or Health Sciences and Technology. Additionally, a Sports Practice encompassing 56 CPs is required. The Sports Practice can be partly conducted during the Bachelor and Master programmes in Sports.

**Assessments**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0101-00L</td>
<td>Assessment Polysports</td>
<td>O</td>
<td>2 credits</td>
<td>2G</td>
<td>M. Altermatt</td>
</tr>
<tr>
<td></td>
<td>Only for BSc Health Sciences and Technology and Teaching Diploma Sports. Compulsory for Teaching Diploma Sports.</td>
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</tbody>
</table>

Abstract

Successful completion of the course “Assessment Polysports” is requirement for access to further practical sport courses. Basic skills in ball games, athletics, gymnastics, fitness, and dance are repeated and tested.

Lecture notes

During the semester the documents are steadily available electronically

**Basic Education**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>557-0412-01L</td>
<td>Dance I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>C. König</td>
</tr>
<tr>
<td></td>
<td>Prerequisites: Assessment I oder Assessment Polysports passed.</td>
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<tr>
<td></td>
<td>Compulsory for Teaching Diploma Sports.</td>
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</table>

Abstract

Dance and movement comprise of expression, strength, endurance, suppleness, flexibility, rhythmic movement sequences, coordination and dance cant with music - combined with creativity. Implementation of these aspects.

Objective

- To arouse and stimulate the interest for dancing
- To enjoy dancing without prior knowledge and to experience the possibilities within dance from easy to hard
- To gain insight into different dance styles
- To improve one's own dance technique in framework of the topics offered: To acquire and expand personal skills and knowledge
- To expand the diversity and repertoire of movements
- To improve coordination with the help of music
- To understand music and to be able to interpret the music's character
- Dance enhances the consciousness about body and posture, helps in a holistic personality development and assists in body language: a way to express emotions

Content

- Kennenlernen von verschiedenen Tanzstilen: HipHop/Streetdance, Jazz, Jive (RNR), Salsa...
- Grundlagen von Techniken einzelner Tanzstile kennenlernen und verbessern
- Erarbeiten von Tanzkombinationen
- Der Tanz und die Bewegung beinhalten Ausdruck, Kraft, Ausdauer, Geschmeidigkeit, Flexibilität, rhythmische Bewegungsabläufe, Koordination und Tanzphasen mit Musik- gepaart mit Kreativität und Lebensfreude

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>557-0433-00L</td>
<td>Apparatus Gymnastics and Trampoline I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>M.-M. Jäggi</td>
</tr>
<tr>
<td></td>
<td>Prerequisites: Assessment I oder Assessment Polysports passed.</td>
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<tr>
<td></td>
<td>Compulsory for Teaching Diploma Sports.</td>
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</tbody>
</table>

Abstract

To get to know and understand the basics of movement (core movements) and its respective actions and functions on apparatuses, on the floor and in acrobatics as well as to create individual and cooperative combinations according to qualitative criteria.

Objective

The students should be able to:
- acquire and consolidate apparatus related core movements as well as apply and create such combinations
- utilize their own strength as well as the resulting impact in a differentiate way in order to precisely move the swinging, flying, falling and twisting body
- gain orientation safety and room orientation while twisting and flying
- gain sensitivity for social competences (e.g. to assist, to observe, to advise) within a small group.

Content

- structural relationships within rotations (turnarounds, handsprings and free somersaults)
- core poses as motor basic training
- variety of position modifications in handstands
- core movements and combinations on parallel bars, high bar, floor and in swinging rings
- different forms of vaulting as well as springing in movements like handstands and somersaults

Literature

- Trampolinschule nach der Part-Methode, BASPO 2013

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>557-0503-01L</td>
<td>Basketball I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>C. Ferrari</td>
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<td></td>
<td>Compulsory for Teaching Diploma Sports.</td>
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</tbody>
</table>
Abstract

Basketball-Basics:
Basic technical skills: dribbling/ballhandling, passing, shooting, footwork and defense related to the specific Basketball rules.
Tactical skills: 1 on 1, give & go, hand-off, pick & roll, pick & pop and the application of these skills in a game 3 on 3 on one basket.

Objective

The students know the technical basic Basketball elements (dribbling, changes of hand, stops, starts, footwork, pass, shot, defense), they can demonstrate them and use them correctly in a game situation 3 on 3 on one basket.
The students know the tactical Basketball elements (1 on 1, give & go, hand-off, pick & roll, pick & pop) and can apply these skills in a game 3 on 3 on one basket.

Content

Learning the basic elements in drills and games, learning (pre-)tactical elements (1-1, getting open, 2-2, backdoor cut, frontdoor cut, 3-3, give & go, hand-off, pick & roll, pick & pop, spacing) and assemble them into systems, that can be used in a game 3 on 3 on one basket.

Literature

mansel for monitors of the Swiss Youth & Sports program (available through the "Jugend & Sport" office, german / french / italian)
Chervet, Michel: Basektball. Fundamental skills for offensive play. Video (german / french). Magglingen, BASPO, 2003 (CHF 34.-). Order at video@baspo.admin.ch

Fostered competencies

Subject-specific Competencies
Concepts and Theories not assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed
Project Management not assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking not assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

557-0514-03L Soccer I
Prerequisites: Assessment III or Assessment Polysports passed.

Abstract

Compulsory for Teaching Diploma Sports.
Acquisition/consolidation basic skills for soccer.
Support and development the individual conditions/talent/skill and introduction of basic methods will be treated.

Objective

Acquisition/consolidation bascile skills in soccer
Support and development the individual conditions/talent/skill and introduction of basic methods want to be at the centre of attention.

Content

Techniques:
Dribble, short passport play, get the ball under control, shot,
Individual tactics:
offensive/defensive 1vs1; keep ball in own rows
various contests in support of different techniques and tactics

Prerequisites / notice
1. Prerequisites:
Small being able in soccer.
Readines to train.

557-0533-01L Floorball I
Prerequisites: Assessment III or Assessment Polysports passed.

Abstract

Experiencing Unihockey/Floorball as an indoor sportsgame
Learning by doing to improve personal sport skills and widening personal abilities in ball sports
Learning by practising/playing and linking that knowledge to theories of motor learning

Objective

Practising unihockey to improve personal sport skills and widening personal abilities in ball sports
Improvement of personal unihockey-skills
Learning by practising/playing and linking that knowledge with theories of motor learning

Content

Transfer of ideas into motor movements and motor skills
Personal improvement by practising different motor skills as moving the ball/ballcontrol, passing, shooting
Training of personal sports abilities in ballgames
Analysis of play-situations and corresponding motor movement
Practical test of skills and in game activities at the end of the semester

Lecture notes
Classes are based on insights from the book "unihockey basics" by B.Beutler, M.Wolf.
ISBN 3-03700-043-0

Please bring your personal hockey stick with you to class.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Type</th>
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</tr>
</thead>
<tbody>
<tr>
<td>557-0522-01L</td>
<td>Handball I</td>
<td>W</td>
<td>2</td>
<td>F. Lüchinger</td>
</tr>
<tr>
<td>Prerequisites: Assessment III or Assessment Polysports passed</td>
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</tr>
<tr>
<td>Abstract</td>
<td>Learn by playing - from three-a-side to four-a-side games. Game development takes place over the zone play of the game (2/1) or 3/2 to the game 4/4 or (6/6). The introduced technical elements form the requirements for the tactically-orientated zone plays and are exclusively trained in the execution and formation steps.</td>
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</tr>
<tr>
<td>Objective</td>
<td>The students improve their personal skills and demonstrate the game in teams as well as groups of 4 against 4. They deepen the development of the game. They improve their personal skills with an individual emphasis on game and practice.</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>Lehrunterlagen können von der Homepage abgerufen werden.</td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Prüfungen Inhalte: Die Prüfungsinhalte werden während des Semesters erarbeitet und am Ende des Semesters online schriftlich zur Verfügung gestellt.</td>
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</tbody>
</table>

557-0603-01L | Snowsports I - Ski | W | 2 | C. Elmiger-Schnyder, further lecturers |
| Prerequisites: Assessment I or II or III or Assessment Polysports passed. 100% presence is required! |
| Registration via Study Administration necessary. Compulsory for Teaching Diploma Sports. |
| Abstract | Education in the disciplines of winter sports. |
| Objective | The students: - experience the different winter sports. - gain an understanding of how to ski off-piste. - Transfer: Input Nordic Cross! |
| Content | - To apply and vary personal technique of alpine skiing - To acquire and vary personal technique of cross-country skiing Competition in ski-jumping, and giant slalom - To gain an understanding in how to ski off-piste - To gain Nordic Cross |

557-0603-02L | Snowsports I - Snowboard | W | 2 | C. Elmiger-Schnyder, further lecturers |
| Prerequisites: Assessment I or II or III or Assessment Polysports passed. 100% presence is required! |
| Registration via Study Administration HST necessary. Compulsory for Teaching Diploma Sports. |
| Abstract | Education in the disciplines of winter sports. |
| Objective | The students: - Experience the different winter sports! - Gain an understanding of how to ski off-piste! - Gain an understanding of how to Nordic Cross. |
| Content | - To apply and vary personal technique of snowboarding - To acquire and vary personal technique of cross-country skiing Competition in ski-jumping, and giant slalom - To gain an understanding in how to ski off-piste - To gain an understanding in how to Nordic Cross |

In-depth Education

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>557-0426-00L</td>
<td>Fitness II</td>
<td>W</td>
<td>2</td>
<td>A. Sonderegger, C. Romano</td>
<td></td>
</tr>
<tr>
<td>Prerequisites: successful completion of basic education in Fitness I.</td>
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<tr>
<td>Registration via Study Administration necessary. Compulsory for Teaching Diploma Sports.</td>
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<tr>
<td>Abstract</td>
<td>Acquisition of further skills and deepened knowledge in the areas of fitness coaching and group fitness.</td>
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</tr>
</tbody>
</table>
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Deepened understanding of the factors that determine human performance and fitness.

Acquisition of personal and methodological skills in the area of fitness coaching and group fitness.

- Anamnese und Trainingsplanung
- Trainingsmittel im Fitnessbereich
- Methoden im Kraft und Ausdauerbereich
- Einführung von Personen an Fitnessgeräten, Instruktion und Korrektur
- Funktionelle Anatomiekenntnisse im Fitnessbereich
- Sicherheits- und Trainingsregeln im Group Fitness
- verbales & visuelles Cueing
- Funktionelles Training im Group Fitness
- Training der Tiefenmuskulatur ohne/mit instabiler Unterlage
- Intervaltraining als Stundenformat
- Koordinationstraining ohne/mit Hilfsmittel
- Dehnmethoden
- Zielgruppenangepasste Stundenformate

Wird im Unterricht abgegeben oder auf Moodle bereitgestellt

- Skript und Unterlagen Fitness I
- Training fundiert erklärt, J. Hegner, 5. Auflage 2012

The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

The students should be able to:
- enhance their repertoire on apparatus specific movements
- deepen their existing store of movements
- improve their individual performance competencies
- realize and comprehend transfer characteristics within the movement learning process
- work up methodically and didactically a chosen skill
- gain sensitivity for social competences (e.g. to assist, to observe, to advise) within a small group
- compose and present to music within a group of three a creative performance
- further core movements und its combinations on different apparatuses
- handsprings and (free) somersaults back- and forwards, respectively twists back- and forwards on different apparatuses
- creative and cooperative composition in a threesome accompanied by music
- vault springs and touching down springs (stuetz springs) to overcome obstacles in an artful way (Freerunning)
- integrated theoretical coherences of the qualitative movement learning process
- conveyance of methodical and didactical principles as well as topic specific criteria
- functional warm-up with regard to specific contents

557-0559-00L  Gymnastics / Acrobatics II  W  2 credits  2G  M.-M. Jäggi

Prerequisite:
Successful completion of the basic education
- “Apparatus Gymnastics and Trampoline I” (557-0433-00L); and
- “Acrobatics I” (557-0432-01L).

Abstract
Acquirement and Application of classic as well as modern forms of movement on different apparatuses and on the trampoline
Application and Creation of established basic skills

Objective
The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

The students should be able to:
- enhance their repertoire on apparatus specific movements
- deepen their existing store of movements
- improve their individual performance competencies
- realize and comprehend transfer characteristics within the movement learning process
- work up methodically and didactically a chosen skill
- gain sensitivity for social competences (e.g. to assist, to observe, to advise) within a small group
- compose and present to music within a group of three a creative performance
- further core movements und its combinations on different apparatuses
- handsprings and (free) somersaults back- and forwards, respectively twists back- and forwards on different apparatuses
- creative and cooperative composition in a threesome accompanied by music
- vault springs and touching down springs (stuetz springs) to overcome obstacles in an artful way (Freerunning)
- integrated theoretical coherences of the qualitative movement learning process
- conveyance of methodical and didactical principles as well as topic specific criteria
- functional warm-up with regard to specific contents

557-0541-00L  Badminton / Volleyball II  W  2 credits  2G  M. Attinger, P. Lüscher Luchsinger

Prerequisite:
Successful completion of the basic education:
- “Badminton I” (557-0601-00L); and
- “Volleyball I” (557-0542-01L).

Abstract
In this course you will build up and experience different tactical and technical exercise forms for classes. At the same time you will be able to deepen your own skills.

Objective
In this course we work on possibilities to build up different tactical and technical exercise forms and structures for classes. You get to know a variety of games. You learn how you can diversify exercises – depending on the level and the age of your pupils.

The level II courses focus on methodological concepts and didactics. The goal is to learn how to teach the specific sport at high school level. The didactical aspects are often conveyed through new skills and elements. It is not required to have passed the level I course, but it is mandatory to have attended it previously.

Prerequisite:
- “Volleyball I” (557-0539-00L); and
- “Application and Creation of established basic skills” (557-0540-00L).

Compulsory for Teaching Diploma Sports!
### Education Acquired Outside ETH

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>557-0450-00L</td>
<td>Life Saving Rescue Test Plus Pool SLRG (Only for Teaching Diploma Sports).</td>
<td>O</td>
<td>2 credits</td>
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<td>external organisers</td>
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<tr>
<td></td>
<td><strong>Confirmation of course attendance Brevet Basis Pool and Brevet Plus Pool SLRG.</strong></td>
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<td></td>
<td><strong>External education! Credit points only for Teaching Diploma Sports!</strong></td>
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<td></td>
<td><strong>Abstract</strong> Acquisition of &quot;SLRG Brevet Plus Pool&quot;.</td>
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<td><strong>Objective</strong> Based on the Brevet Basic Pool, the Brevet Plus Pool provides you with skills to supervise groups in unguarded pools.</td>
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<td>- <strong>To recognize danger in, on and around water</strong></td>
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<td></td>
<td>- <strong>Knowledge and handling of life saving equipment</strong></td>
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<td></td>
<td>- <strong>Rescue and towing techniques</strong></td>
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<td>- <strong>Orientation under water</strong></td>
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<td>- <strong>To rescue a person</strong></td>
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<td></td>
<td>- <strong>Basis knowledge in anatomy and first aid</strong></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Prerequisites: please consult <a href="http://www.slrg.ch">www.slrg.ch</a></td>
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<td>557-0451-00L</td>
<td>First Responder Level 2 (Only for Teaching Diploma Sports).</td>
<td>O</td>
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<td><strong>Confirmation of course attendance &quot;First Responder Level 2 IVR&quot;.</strong></td>
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<td><strong>More information: <a href="http://www.samariter.ch">www.samariter.ch</a></strong></td>
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<td><strong>External education! Credit points only for Teaching Diploma Sports!</strong></td>
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<td><strong>Abstract</strong> Acquisition of the certificate &quot;Ersthelfer Stufe II IVR&quot;.</td>
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<tr>
<td></td>
<td><strong>Objective</strong> In this course you will acquire the basic knowledge related to safety and hygiene measures in case of injuries and acute illnesses.</td>
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<tr>
<td></td>
<td>- <strong>To be able to judge an injured person and to apply life saving actions</strong></td>
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<td></td>
<td>- <strong>To carry out wound treatment with actual bandage</strong></td>
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<td></td>
<td>- <strong>To list the characteristics of a sprain, strain, dislocation and to apply first-aid interventions</strong></td>
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<tr>
<td></td>
<td>- <strong>To carry out fixed bandages with common material</strong></td>
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<td>- <strong>To explain the function of the cardiovascular system</strong></td>
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<td></td>
<td>- <strong>To name the symptoms of poisoning</strong></td>
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<td>- <strong>To list the signs of acute illness</strong></td>
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<td>- <strong>To put together the content of a first-aid box</strong></td>
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<td></td>
<td>- <strong>To carry out safety interventions in daily situations.</strong></td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<td></td>
<td>- <strong>Hautverletzungen</strong></td>
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<td></td>
<td>- <strong>Wundinfektion / Blutvergiftung</strong></td>
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<td></td>
<td>- <strong>Stürze im Alltag</strong> (Verstauchungen, Prellungen, Quetschungen)</td>
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<tr>
<td></td>
<td>- <strong>Sportverletzungen, Knochenbrüche</strong></td>
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<td></td>
<td>- <strong>Herzkreislauftörungen</strong></td>
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<td></td>
<td>- <strong>Alltagserkrankungen in der Familie</strong></td>
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<td><strong>Prerequisites / notice</strong></td>
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<td>Prerequisites: please consult <a href="http://www.samariter.ch">www.samariter.ch</a></td>
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<tr>
<td>557-0452-00L</td>
<td>J+S-Coach School and Youth Sports (Only for Teaching Diploma Sports).</td>
<td>O</td>
<td>2 credits</td>
<td></td>
<td>external organisers</td>
</tr>
<tr>
<td></td>
<td><strong>Abstract</strong> Acquisition of the certificate &quot;J+S-Coach School and Youth Sports&quot; in the course of &quot;Magglinger Hochschulwochen&quot;.</td>
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<td></td>
<td><strong>Objective</strong> - <strong>to experience and reflect on qualitatively good sports using practical examples.</strong></td>
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<tr>
<td></td>
<td>- <strong>to get to know the institution BASPO/EHSM with its tasks and network.</strong></td>
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<td>- <strong>to get to know the J+S program.</strong></td>
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<td>- <strong>to gain proficiency as a J+S Coach in school and youth sports.</strong></td>
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</table>

### Compensation Courses

<table>
<thead>
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<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>557-0603-01L</td>
<td>Snowsports I - Ski (Prerequisites: Assessment I or II or III or Assessment Polysports passed. 100% presence is required!)</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>C. Elmiger-Schnyder, further lecturers</td>
</tr>
<tr>
<td></td>
<td><strong>Registration via Study Administration necessary.</strong></td>
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<tr>
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<td><strong>Compulsory for Teaching Diploma Sports.</strong></td>
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<tr>
<td></td>
<td><strong>Abstract</strong> Education in the disciplines of winter sports.</td>
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<tr>
<td></td>
<td>- <strong>J+S Education possibility</strong></td>
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<td></td>
<td>- <strong>Transfer Offpist</strong></td>
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<tr>
<td></td>
<td>- <strong>Transfer Nordic Cross</strong></td>
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</tbody>
</table>
Objective

The students:
- experience the different winter sports.
- gain an understanding of how to ski off-piste.
- Transfer: Input Nordic Cross!

Content

- To apply and vary personal technique of alpine skiing
- To acquire and vary personal technique of cross-country skiing
- Competition in ski-jumping, and giant slalom
- To gain an understanding in how to ski off-piste
- To gain understanding in how to Nordic Cross

557-0605-01L

Rainbow

Prerequisite: Basic course Snowsports I - Ski passed. 2 credits 2G

C. Elmiger-Schnyder, further lecturers

Abstract

Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports.

Objective

Snow sports Skiing:
- To deepen and expand experience and skills in snow sports and in the personal competency of technique of the chosen snow sport.

Content

Snow sports (snowboarding):
- General and specific education of personal competency in technique of the chosen snow sport: Park, Piste and Off-Piste

Prerequisites / notice

Requirement: Basic course in Snowsport I completed.

557-0605-02L

Rainbow

Prerequisite: Basic course Snowsports I - Snowboard passed. 2 credits 2G

C. Elmiger-Schnyder, further lecturers

Abstract

Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports.

Objective

Snow sports Skiing:
- To deepen and expand experience and skills in snow sports and in the personal competency of technique of the chosen snow sport.

Content

Snow sports (snowboarding):
- General and specific education of personal competency in technique of the chosen snow sport: Park, Piste and Off-Piste

Prerequisites / notice

Requirement: Basic course in Snowsport I completed.

557-0605-03L

Rainbow

Prerequisite: Basic course Snowsports I - Telemark passed. 2 credits 2G

C. Elmiger-Schnyder, further lecturers

Abstract

Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports.

Objective

Snow sports:
- To deepen and expand experience and skills in snow sports and in the personal competency of technique of the chosen snow sport.
- To expand skills to the area of telemark

Content

Snow sports:
- General and specific education of personal competency in technique of the chosen snow sport.
- Telemark as an extra experience in the framework of technique on slope, park and off-piste.

Prerequisites / notice

Requirement: Basic course in Snowsport I completed.

557-0605-04L

Rainbow

Prerequisite: Basic course Snowsports I - Off-Piste passed. 2 credits 2G

C. Elmiger-Schnyder, further lecturers

Abstract

Specialization training: Acquisitions of special skills, getting to know the performance factors and training methods in the areas of Snowsports.

Objective

Snow sports:
- To deepen and expand experience and skills in snow sports and in the personal competency of technique of the chosen snow sport.
- To expand skills to the area of telemark

Content

Snow sports:
- General and specific education of personal competency in technique of the chosen snow sport.
- Telemark as an extra experience in the framework of technique on slope, park and off-piste.

Prerequisites / notice

Requirement: Basic course in Snowsport I completed.
### Additional Requirements in Sports Science

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-0203-00L</td>
<td>Movement and Sport Biomechanics</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>B. Taylor, R. List</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Learning to view the human body as a (bio-) mechanical system. Making the connections between everyday movements and sports activity with injury, discomfort, prevention and rehabilitation.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Students are able to describe the human body as a mechanical system. They analyse and describe human movement according to the laws of mechanics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>Movement- and sports biomechanics deals with the attributes of the human body and their link to mechanics. The course includes topics such as functional anatomy, biomechanics of daily activities (gait, running, etc.) and looks at movement in sport from a mechanical point of view. Furthermore, simple reflections on the loading analysis of joints in various situations are discussed. Additionally, questions covering the statics and dynamics of rigid bodies, and inverse dynamics, relevant to biomechanics are investigated.</td>
<td></td>
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</tr>
<tr>
<td><strong>Literature</strong></td>
<td>Online material is provided during the course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lecture notes</strong></td>
<td>Wird in der Vorlesung bekannt gegeben.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prerequisites / notice</strong></td>
<td>Requirement: Basic course in Snowsport I completed.</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

| 376-0207-00L| Exercise Physiology                        | W    | 4    | 3G    | C. Spengler, F. Gabe Beltrami |
| **Abstract**| This course provides an overview over molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interactions of the different systems influencing factors, e.g. genetics, gender, age, altitude/depth, heat/cold, with respect to performance and health. |
| **Objective**| The aim of this course is to understand molecular and systemic aspects of neuromuscular, cardiovascular and respiratory adaptations to acute and chronic exercise as well as the interaction of the different systems regarding health-relevant aspects and performance in healthy people and persons with selected diseases. Furthermore, students will understand the influence of genetics, gender, age, altitude/depth, heat and cold on the named factors. |
| **Content**| History of Exercise Physiology, research methods, fiber-type heterogeneity and its functional significance, neural control of muscle force, molecular and cellular mechanisms of muscle adaptation to resistance, endurance and stretching exercise, interindividual variability in the response to training, cardiorespiratory and metabolic responses to acute and chronic exercise, sex differences relevant to exercise performance, exercise in hot and cold environment, children and adolescents in sport and exercise, exercise at altitude and depth, aging and exercise performance, exercise for health, exercise in the context of disease. |
| **Lecture notes**| Ein Skript für die aktuelle Veranstaltung wird abgegeben. |
| **Literature notes**| Literaturangaben für eine Vertiefung der Inhalte werden im Skript gemacht. Die Anschaffung von Spezialliteratur ist allerdings nicht notwendig. |

| 376-1033-00L| History of Sports                          | W    | 2    | 2V    | M. Gisler          |
| **Abstract**| Comprehension for development and changes of sports from the ancient world to the present. Description of sports in services of national idea, from education and health promotion from the middle of the 18th century till this day. |
| **Objective**| Understanding for the development and adaptation of sports from the ancient world to present times. |
| **Lecture notes**| Ein Skript für die aktuelle Veranstaltung wird abgegeben. |
| **Literature notes**| Literaturangaben für eine Vertiefung der Inhalte werden im Skript gemacht. Die Anschaffung von Spezialliteratur ist allerdings nicht notwendig. |

| 376-1107-00L| Sport Pedagogy                             | W    | 2    | 2V    | C. Herrmann        |
| **Abstract**| The teacher-student interaction presents a complex psychosocial event, demonstrating the need for a psychological extension of the classical social science / sports pedagogical perspective. Therefore, this lecture will be focused on "pedagogical-psychological aspects of competence development in the context of a multi-perspective physical education". |
| **Objective**| Development of pedagogical-psychological competences for the optimisation of future teaching activities. |
| **Content**| - Subject area of educational psychology  
- Motivating students in physical education  
- Building self-efficacy and strengthen the self-concept  
- Promoting positive emotions and a positive attitude to anxiety  
- Encouraging self-directed learning  
- Leading classes and promoting cooperation  
- Communicating with students efficiently  
- Reflecting your own expectations critically  
- Handling gender issues sensitively  
- Promoting inclusion / Strengthening social and moral development  
- Dealing with difficult students  
- Evaluating achievements of students |
| **Lecture notes**| Teaching materials for the individual lectures are provided to the students via moodle. |
| **Literature**| Primärliteratur  

| 376-1117-00L| Sport Psychology                           | W    | 2    | 2V    | H. Gubelmann, C. Baldasare Ackermann, P. Müller |
| **Abstract**| This lecture is intended as an introduction to sport psychology and imparts knowledge on selected areas of the subject. |
During the lecture students get acquainted with different scientific and practical methods of functional and biomechanical movement. These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives. The lectures set out to:

- present the different dimensions, functions and interrelationships of present-day sport
- develop the understanding of physiological processes in response to physical exertion.
- show how far sport reflects society and how it changes and becomes more differentiated in the process.
- take current examples to highlight the sociological view of sport.

**Content**

- Social inequalities and distinctions: gender differences and group behavior
- The economy and the media: dependencies, consequences, scandals

**Objective**

- Students are given insight into different work areas of sport psychology. In order to understand what «sport psychology» is, it is necessary to explain the essence and tasks of sport psychology and what it relates to, and to work out an underlying basis for key topics, such as cognition and emotions. Students’ expertise is furthered by presenting and providing more in-depth treatment of additional topics of sport psychology. Selected intervention forms are intended to provide insight into applied sport psychology and ensure that mental processes and their impact in sport can be recognised. Case studies and practical exercises (e.g. objective training) are intended to prompt students to reflect to a greater extent on the forms in which sport psychology can be applied in their practice of sports and to integrate these in their teaching.

**Content**

- Social inequalities and distinctions: gender differences and group behavior
- The economy and the media: dependencies, consequences, scandals

**Literature**


**List of lecture notes**

- Various exercise tests assessing human performance and assessments of physiological responses to activity (examples are VO2max-test, Conconi-Tests, Determination of anaerobic threshold, Cooper-Test, 1-repetition maximum test, lactate minimum test), dynamometry, mechanography, body composition etc.). Insight into measurements in Sports Medicine.

**Literature**

- Kenney/Wilmore/Costill: Physiology of Sport and Exercise, Human Kinetics
- Schmidt/Lang/Heckmann: Physiologie des Menschen, Springer-Verlag, Heidelberg

**Prerequisites / notice**

- Anatomy and physiology classes and lab course in physiology successfully completed (BWS students please contact C. M. Spengler)
- In the first phase of the lecture, the different approaches are presented and applied. In the process, current technical devices will be used. In a second phase, individual projects are worked out in small teams. The projects will be discussed, presented and graded.

**Lecture notes**

- Class material will be distributed using the moodle platform.
## Sport Teaching Diploma - Key for Type

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
</tr>
<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
</tr>
</tbody>
</table>

## Key for Hours

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
</tr>
<tr>
<td>U</td>
<td>exercise</td>
</tr>
<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

### ECTS

European Credit Transfer and Accumulation System

- Special students and auditors need special permission from the lecturers.
### Public Policy Bachelor

**1. Semester**

#### Core Courses First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0723-00L</td>
<td>Introduction to Torts, Contracts and Insurance Law</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>C. von Zedtwitz</td>
</tr>
<tr>
<td></td>
<td>Only for Public Policy BA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to Torts, Contracts and Insurance Law.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The course shall make sure that the participants are fit to make the adequate decisions when encountering legal questions and issues in their career.</td>
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</tr>
<tr>
<td>Content</td>
<td>In order to achieve this goal, legal problems and issues will be presented to the participants and then discussed in class.</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>The course touches upon relevant topics of Contract Law (formation of contract and contract performance). Tort Law (including liability limitation), corporate law (types of corporations, formation of LLC), civil procedure (jurisdiction and applicable law, costs, when and how to engage a lawyer) and insurance law (duty to disclose relevant facts, gross negligence).</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The course 'Introduction au Droit civil' (851-0709-00) provides an introduction to the law of Contracts and Torts in French.</td>
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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0709-00L</td>
<td>Introduction to Civil Law</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>H. Peter</td>
</tr>
<tr>
<td>Abstract</td>
<td>The course Private Law focuses on the Swiss Code of Obligations (contracts, torts) and on Property Law (ownership, mortgage and easements). In addition, the course will provide a short overview of Civil Procedure and Enforcement.</td>
<td></td>
<td></td>
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<tr>
<td>Objective</td>
<td>Teaching of the principles of law, particularly private law. Introduction to law.</td>
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</tr>
<tr>
<td>Content</td>
<td>The law of civil property in particular respects the rights of the owner (contracts and responsibility). However, it is also given in the area of civil procedure and enforcement.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Literature</td>
<td>Éditions officielles récentes des lois fédérales, en langue française (Code civil et Code des obligations) ou italienne (Codice civile e Codice delle obbligazioni); disponibles auprès de la plupart des bibliothèques.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The course 'Introduction au Droit civil' (851-0709-00) provides an introduction to the law of Contracts and Torts in French.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0577-00L</td>
<td>Principles of Political Science</td>
<td>O</td>
<td>4</td>
<td>2V+1U</td>
<td>T. Bernauer</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers basic questions, concepts, theories, methods, and empirical findings of political science.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Objective</td>
<td>This course covers basic questions, concepts, theories, methods, and empirical findings of political science.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The Kurs basiert auf dem Lehrbuch «Einführung in die Politikwissenschaft» von Bernauer et al. Jede Kurseinheit konzentriert sich auf ein bis zwei Kapitel dieses Buches, das die Studierenden vor der betreffenden Kurseinheit lesen müssen. Die 5. Auflage dieses Lehrbuches ist ca. ab Anfang September 2022 via Buchhandlungen oder online erhältlich.</td>
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</tbody>
</table>

**Examinations Block 1**

*Students are free to take the exam either in German or in French. They may choose between 853-0723-00L ‘Introduction to Torts, Contract and Insurance Law’ or 851-0709-00L ‘Introduction to Civil Law’ (French)*

**Autumn Semester 2022**

**Core Courses**

- **851-0709-00L Introduction to Civil Law**
- **853-0723-00L Introduction to Torts, Contracts and Insurance Law**

**Exam Block 1**

- **Examination Period:**
  - Type: Only for Public Policy BA
  - Hours: 2V
  - Lecturers: C. von Zedtwitz

**ECTS:**

- 4 ECTS (Zeitaufwand insgesamt ca. 120 Arbeitsstunden)

**Prerequisites:**

- The course provides an introduction to the law of Contracts and Torts in French.

**Literature:**

- The course touches upon relevant topics of Contract Law (formation of contract and contract performance). Tort Law (including liability limitation), corporate law (types of corporations, formation of LLC), civil procedure (jurisdiction and applicable law, costs, when and how to engage a lawyer) and insurance law (duty to disclose relevant facts, gross negligence).

**Prerequisites / notice:**

- The course 'Introduction au Droit civil' (851-0709-00) provides an introduction to the law of Contracts and Torts in French.

**Examinations:**

- **First Exam:**
  - Type: Only for Public Policy BA
  - Hours: 2V
  - Lecturers: H. Peter

**Remarques:**

- Remarques
  - Le cours de droit civil porte notamment sur le droit des obligations (droit des contrats et responsabilité civile) et sur les droits réels (propriété, gages et servitudes). De plus, il est donné un bref aperçu du droit de la procédure et de l'exécution forcée.
  - Les examens peuvent se faire en français ou en italien.
  - Examen au 1er propédeutique; convient pour travail de semestre.
  - Con riassunti in italiano. E possibile sostenere l'esame in italiano.

**Number**

- 851-0577-00L Principles of Political Science

**Type**

- O

**ECTS**

- 4

**Hours**

- 2V+1U

**Lecturers**

- T. Bernauer

**Prerequisites / notice:**


**Tipp:**


**Leistungskontrollen:**

- a) Erster Test (...)
- b) Zweiter Test (...)

**Kreditpunkte:**

- 4 ECTS-Punkte (Zeitaufwand insgesamt ca. 120 Arbeitsstunden)

**Lecture notes:**


**Pro Kurseinheit:**

- (Woche) sind ca. 30–40 Seiten zu lesen. Für einzelne Kurseinheiten müssen Sie etwas mehr lesen (zwei Buchkapitel, ca. 60–80 Seiten insgesamt). Es lohnt sich also, bereits von Anfang des Kurses an ein wenig «auf Vorrat» zu lesen.

**Weitere Lehrmaterialien finden Sie auf:**

- http://www.ib.ethz.ch/teaching/pwgrundlagen

**Data:** 01.11.2022 12:41

**Autumn Semester 2022**

**Page:** 2115 of 2416
Leadership I
For BA Public Policy and DAS Military Sciences only.

Abstract
The lectures "Leadership I" (WS) and "Leadership II" (SS) have been designed as a two-semester lecture series, but may also be followed independently of one another or in reverse order. "Leadership I" covers the following fields: leadership basics, leadership theories and leadership styles, the concept of leadership responsibility and the role of communication in practical leadership.

Objective
The aim of this lecture is to give students an introductory overview of relevant topics regarding leadership research and practice, thus enabling them to gain a deeper understanding of the leadership phenomenon. Students should understand different concepts of leadership in the complex interaction between individuals, groups, organisation, context and situation. They should be informed about the evolution of leadership theory in the past 100 years. They should grasp the concept of leadership responsibility (leadership ethics) and be able to derive consequences for leadership in practical situations. They should recognize the fundamental importance of communication in leadership situations and receive input which enables them to communicate adequately in specific situations.

##### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>351-1034-00L</td>
<td>Microeconomics ■ ■ Not for students belonging to D-MTEC!</td>
<td>O</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Fetz, M. Gysler</td>
</tr>
</tbody>
</table>

Abstract
Introduction to the economic decisions of households and firms, and their coordination through markets. Analysis of different market structures and of situations in which markets may lead to socially undesirable outcomes.

Objective
Understanding of basic microeconomic models. Ability to apply these models to real world economic situations.

Content
Economics as a science, division of labour and welfare (concept of comparative advantage), supply and demand (market equilibrium, elasticity), households (kindness in relation to working processes and its impact on organizations and the understanding of leadership theory in the past 100 years. They should grasp the concept of leadership responsibility (leadership ethics) and be able to derive consequences for leadership in practical situations. They should recognize the fundamental importance of communication in leadership situations and receive input which enables them to communicate adequately in specific situations.
Examine the fundamentals of the two sciences and establish links with military life. Discuss various schools of thought in psychology and related fields. The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and techniques. 

Leadership and Responsibility

ECTS

At the end of this lecture course, students can: (a) highlight the most important changes in the "long nineteenth century" in Europe (b) explain their long-term effects; and (c) relate these changes to global developments today.

Content

The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.

Lecture notes

Power Point Slides and references will be made available in digital form during the course of the semester.

Prerequisites / notice

This lecture series does not build upon specific previous knowledge by the students.

853-0037-00L Military Psychology and Pedagogy I

Only for Public Policy BA

Abstract

Examine the fundamentals of the two sciences and establish links with military life. Discuss various schools of thought in psychology and related fields. The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.

Objective

- Knowing the possibilities and limitations of military education and deriving consequences
- Knowing content- and process theories of motivation and being able to transfer them to the military context
- Knowing the possibilities and limitations of military education and deriving consequences
- Defenceness-, service-, operational- and combat motivation
- Swiss military pedagogy
- Education as defining feature of pedagogic thinking
- History of military psychology
- Psychological images of humanity (psychoanalysis, behaviourism, behavioural biology, humanistic psychology, cognitivism)
- Motivational theories
- Education as defining feature of pedagogic thinking and acting

Content

Overall, the objective is to become acquainted with the basics of both scientific areas and to make references to military practice. Military psychology is a branch of applied psychology; consequently selected aspects of psychological principles will be covered. Military pedagogy hasn't yet established itself firmly as an independent scientific discipline, it nevertheless can draw on a deep-seated tradition in Switzerland. Thus, the great importance that has been attached to the discussion of education in Swiss society and academia will be taken into account. Subjects:

- History of military psychology
- Psychological images of humanity (psychoanalysis, behaviourism, behavioural biology, humanistic psychology, cognitivism)
- Motivational theories
- Defence-, service-, operational- and combat motivation
- Swiss military pedagogy
- Education as defining feature of pedagogic thinking

This course is completed by a compulsory one week course between terms.

Literature

- Annen, H., Steiger, R. & Zwygart, U.: Gemeinsam zum Ziel, Huber, Frauenfeld 2004 (provided as pdf)
- Stadelmann, J.: Führung unter Belastung, Huber, Frauenfeld 1998 (provided as pdf)

The course is supported by a virtual learning environment containing relevant documents (presentations and texts) and information to further literature.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

853-0205-00L Proseminar I: Political Methodology ■

Only for Public Policy BA

Abstract

Teaching of formal requirements of scientific work (philosophy of science with a focus on the social sciences); literature reviews and the basics of conducting independent research on short as well as simple topics; basics of conceptualizing research designs for politically relevant questions and hypotheses.
This three-semester English course should enable the participants to successfully use the English language in an international military setting.

Content
Political Methodology I seeks to introduce students to the basics of scientific work and procedures in the social sciences, which in turn shall allow them - also in conjunction with Political Methodology II - to conduct work that fulfills satisfactory standards of research quality throughout their further studies.

With regard to Political Methodology I, this seminar primarily focuses on the philosophy and theory of (empirical social) sciences, its structure, and procedures. The seminar emphasizes substantive contents and ways of presenting them, research and, conceptual work. Additionally, it deals with the basis of establishing research designs with politically relevant questions and hypotheses.

Societal change; organizations as societal phenomena; aims, structures, environments of organizations; specifics of the military as an organization; impacts of technological and societal changes on the armed forces in modern societies.

Conflict Research I: Political Violence

Beside of the most important terms of sociology, demographic changes and the related value and structure change will be analysed. The second part focuses on organizational sociology. Thirdly, the course examines to which extent armed forces can be considered as organizations like any other and to which extent they constitute a special case from an organizational and normative point of view.

Literature


Prerequisites / notice
Each student will be graded by two exercises (50% each).

1) Source analysis and acquisition: based upon a research question that will be given by the lecturer, the student shall collect a comprehensive list of the relevant literature and summarize that with her/his own words.

2) Critical analysis of sources: based upon a research article that the student chooses on her/his own, the student shall write a critical analysis of that, which mirrors frame and structure of scientific writing

Submission dates will be communicated in the first meeting.

853-0064-00L
Military Sociology I

3 credits

2V

T. Szvircsev Tresch, S. De Rosa, T. Ferst

Beside of the most important terms of sociology, demographic changes and the related value and structure change will be analysed. The second part focuses on organizational sociology. Thirdly, the course examines to which extent armed forces can be considered as organizations like any other and to which extent they constitute a special case from an organizational and normative point of view.

Literature
A reader with a set of texts will be handed out.

Fostered competencies

Subject-specific Competencies

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Decision-making

Media and Digital Technologies

Problem-solving

Project Management

Communication

Cooperation and Teamwork

Customer Orientation

Leadership and Responsibility

Self-presentation and Social Influence

Sensitivity to Diversity

Negotiation

Personal Competencies

Adaptability and Flexibility

Creative Thinking

Critical Thinking

Integrity and Work Ethics

Self-awareness and Self-reflection

Self-direction and Self-management

Objective
Recognize and explain current changes (social change) in modern society (individualisation, pluralisation); describe demographic changes in Switzerland; explain the structures of societies; define issues and fields of research in modern military sociology and explain the foundations of organisational sociology; explain the military in terms of organisational sociology and identify specific traits of the military as an organisation.

Content
Societal change: organizations as societal phenomena; aims, structures, environments of organizations; specifics of the military as an organization; impacts of technological and societal changes on the armed forces in modern societies.

Languages

First Foreign Language

English, Part I

Only for Public Policy BA

3 credits

4G

S. Schweizer

Abstract
Teaching is focused on the acquisition of general English in the four classical skills, i.e. speaking, listening comprehension, reading comprehension and writing. The goal is to reach level B2 or C1 depending on the linguistic proficiency of the students.

Objective
This three-semester English course should enable the participants to successfully use the English language in an international military setting.

Content
Read, analyse and write military and civilian documents

Listening comprehension using current radio or TV reports

Practise speaking through group discussions and short presentations

Systematic revision and extension of key grammar points

Systematic acquisition of general and military vocabulary

3. Semester

Remaining Core Courses of the Bachelor Programme

Conflict Research I: Political Violence

Only for Public Policy BA.

4 credits

2V+1U

A. Juon, Y. Weissberg

Number
853-0015-00L

Title
Conflict Research I: Political Violence

Only for Public Policy BA.

ECTS
4

Hours
2V+1U
Abstract
Introduction to research on political violence in domestic and international politics. This course covers the causes and solutions to different types of political violence including interstate wars, civil wars, terrorism or social protests.

Objective
Knowledge on different types of political violence and their causes.

Content
This course offers an introduction to research on the causes and solutions to political violence in domestic and international politics. First, we discuss the definitions and concepts used in conflict research, the data and methods commonly applied and their historical development. Second, we focus on interstate wars and examine in this context state formation, nationalism and democracy. The third part of the course focuses on different types of political violence, including civil war, terrorism or social protests.

Prerequisites / notice
The course «Conflict Research II» in the following semester further examines civil wars.

Exercises complete the lectures, where the literature will be further discussed. The participants write a short memo (max. 3 pages) about one of the required readings.

853-0047-00L
World Politics Since 1945: The History of International Relations
Only for Public Policy BA and DAS Military Sciences

Abstract
This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.

Objective
By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.

Content
- Distinguish between military history as a subject and historiography as a way of describing events;
- Exemplify the issues regarding the evolution of the combat (First and Second World War, Vietnam War and Algerian War);
- Based on the approach regarding revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Reflection of common business practices.

Prerequisites / notice
The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos (oliver.roos@spio.gess.ethz.ch)

853-0065-00L
Business Administration I
Only for Public Policy BA

Abstract
The course BA I provides an understanding of the principles of General Business Management. It comprises an introduction to the basic business principles within a business acumen with a clear focus on value creation. The theory conveyed is illustrated with exercises, case studies and examples from business practice.

Objective
- Understanding and application of instruments and methods of general management.
- Driving customer equity.
- Reflection of common business practices.

Content
I ENTERPRENEURIAL THINKING AND ACTION
1. Customer orientation and value creation
2. Business and Environment
3. Legal forms of business under Swiss corporate law

II BUSINESS PROCESSES
4. Marketing I
5. Marketing II

III SUPPORTING PROCESSES
6. Human Resource Management I
7. Human Resource Management II

IV MANAGEMENT PROCESSES
8. Organisation
9. Value-based management
10. Mission, Business Norms and Business Culture
11. Strategic Management

Literature


853-0063-00L
Military History I
Only for Public Policy BA

Abstract
The lecture outlines the development of the armed forces (assets regarding manpower, technology and armament), the concepts of warfare and the actual warfare in the 19th and 20th century.

Objective
- Distinguish between military history as a subject and historiography as a way of describing events;
- Analyse the modern developments regarding armed forces and warfare in the context of socio-economic changes;
- Based on the approach regarding revolution in military affairs, describe the evolution of the armed forces and of warfare;
- Exemplify the issues regarding the evolution of the combat (First and Second World War, Vietnam War and Algerian War).

Content
The lecture first examines the bases of the science of (military) history. It focuses on how military history developed from war history, on specific similarities and differences between military history and general historiography, the different ways of dealing with history in Switzerland, Germany, France and in the Anglo-Saxon cultural area (different approaches) as well as on institutions which deal with military history such as universities, military academies, national and international commissions and associations etc.

The lecture is structured along the lines of the concept of "Military Revolution" and starts with the formation of modern, European armed forces after the Oranian Army reform in the 17th century.

Based on the "Military Revolution" approach, the lecture examines the structural changes regarding the armed forces and the development of warfare from the 18th to the 20th century. Special emphasis will be put on how the battlefield was revolutionized due to the Napoleonic wars, the industrialization in the 19th century, the First World War, the mechanization and totalization during the Second World War and the period of the Cold War.

Literature

853-0082-00L
Strategic Studies I

Abstract
The lecture series treats high-impact strategic theory from antiquity to the present.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2119 of 2416
The participants know how the understanding of strategy has evolved over time. They understand the interplay of strategy's basic components: ends, ways, means. They know the most important classics of strategy and war theory, especially against their specific historical background. Based on the analysis of historical and contemporary examples, they are aware of the mismatch between declaration and implementation of any given strategy. They are capable of analyzing original texts and modern scholarly works in the field of strategic studies.

The two-semester lecture series treats classic texts of strategic studies from antiquity to the present. Term 1 covers the theories until roughly 1900, term 2 treats the theories thereafter. Theories are considered classic if they were prominent in their respective times and if they enjoyed a strong reception thereafter, be it in literature, in academic debates or as guidelines for action. Each out of some 50 theories is discussed in three steps: historical context, core elements and reception.

Prior to the lectures, the respective slides are provided as well as primary sources and literature, as preparatory readings (via Moodle). The program is also available online (via MSTL).


ISBN 978-3-658-06146-3

- German language: ISBN 978-3-658-06146-3

- German language: ISBN 978-3-658-06146-3

- German language: ISBN 978-3-658-06146-3
The students can

Introduction to Constitutional Law in Security Policy

The lecture deals with questions of competence and the security policy instruments in the federal state, conveys the basic principles of

The lecture consists of three parts: Basics, Security policy instruments, Consolidation.

- outline the basic constitutional order for Swiss security policy, identify the competences of the Confederation and assess the advantages and disadvantages of this basic order;
- explain and evaluate special legal forms of action;
- distinguish the tasks of security policy actors and assess forms of cooperation;
- derive legal limitations for operations of the armed forces from the Federal Constitution;
- identify the basic principles and individual special aspects of military-civilian cooperation;
- identify the police powers of the armed forces and determine the permissibility of using forms of coercion;
- describe the legal status of members of the armed forces and explain the special responsibility of officers;
- establish the relationship between the actions of state actors and the guarantee of fundamental rights;
- assess current challenges in security law.

The last hour before the examination is reserved for revision and questions.

The basic source of the lectures is (purchase recommended):
- Gianfranco Albertini/Thomas Armbruster/Beat Spörri, Militärisches Einsatzrecht, Zürich 2016 (ISBN 978-3-7255-7080-5; around CHF 89.-)

The required reading will be listed at the beginning of the semester.

The course will be supported by an e-learning environment.

The students can

Lecture notes

- Systematic acquisition of general and military vocabulary
- Systematic revision and extension of key grammar points
- Practise speaking with group discussions and short presentations
- Systematic acquisition of general and military vocabulary

Content

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The required reading will be listed at the beginning of the semester.

The course will be supported by an e-learning environment.

The students can
Seminar II builds on the findings of seminar I. Within the broader framework of the overall theme of the seminar (Foreign Policies and Security Strategies of the Great Powers) and based on the approved research design of seminar I, participants write their term paper (in close consultation with the lecturer).

**Lecture notes**
A Reader was provided as part of seminar I (cf. online platform Moodle).

**Literature**
cf. Reader and Reading List Seminar I

**Prerequisites / notice**
German

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
<th>Credits</th>
<th>Type</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0061-00L</td>
<td>Introduction to Cybersecurity Politics</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>M. Dunn Cavelty, F. J. Egloff</td>
</tr>
</tbody>
</table>

**Abstract**
The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

**Objective**
Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.

**Content**
We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulartory contexts).

**Lecture notes**
A script with background information and comments on the literature will be made available at the beginning of the semester.

**Literature**
Literature for each session will be available on Moodle.

The lecture is being supported by a website on Moodle.

**Fostered competencies**
Subject-specific Competencies
- Concepts and Theories
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Method-specific Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Social Competencies
- Creative Thinking
- Critical Thinking

Personnel Competencies
- Self-direction and Self-management

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>853-0046-00L</td>
<td>Social Psychology of Groups</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>T. Heilmann</td>
</tr>
</tbody>
</table>

**Abstract**
Basic social psychological topics are elaborated, presented, and discussed in the most application-oriented way.

**Objective**
You are able to recognize and explain various social psychological aspects and factors and to evaluate them in your everyday decisions in terms of planning, content and operations. This means you will be able to assess when various social psychological aspects may play a role in your everyday work. And you are able to assess what this may subsequently mean for your work or leadership processes.

**Content**

1) Führungspychologie: Kurzer Einblick in neuere Führungstheorien.
2) Destructive Führung: Was sollten wir nicht machen?
3) Soziale Kognition: Warum und auf Basis welcher wenig Informationen wir sehr schnell Urteile über Personen treffen.
4) Soziale Wahrnehmung/Attribution: Wie erklären wir uns, dass sich jemand im Alltag in gewisser Art und Weise verhält?
5) Diversity & Frauen & Führung: Woran kann es liegen, dass weibliche Führungskräfte besondere Herausforderungen bei der Ausübung von Führung haben?
6) Sozialer Einfluss: Welche Normen erleben Sie beim Militär? Und wie leiten diese Erwartungen unser Verhalten im Berufsalltag?
7) Gruppenspsychologie: Was heisst "Gruppe"? Wie entwickeln sich (militärische) Gruppen, z.B. in der RS? Welche Prozesse können zwischen Gruppen geschehen?
9) Überzeugungsstrategien
Literature


Languages

Second Foreign Language

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>853-0402-00L</td>
<td>German, Part II</td>
<td>W</td>
<td>3 credits</td>
<td>4G</td>
<td>S. Schweizer</td>
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<td></td>
<td>Only for Public Policy BA</td>
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<tr>
<td>Abstract</td>
<td>Based on the knowledge and skills acquired during the first semester, speaking and discussion skills related to military situations are examined and put into practice. Attention is focused on issues such as instruction, qualification and career interviews.</td>
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<tr>
<td>Objective</td>
<td>This two-semester German course should enable the French and Italian speaking participants to fulfil their function as professional officers also in the German language.</td>
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</tr>
<tr>
<td>Content</td>
<td>Read, analyse and write military and civilian documents</td>
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<tr>
<td></td>
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<td>Practise speaking with group discussions and short presentations</td>
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<td></td>
<td>Systematic revision and extension of key grammar points</td>
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<tr>
<td></td>
<td>Systematic acquisition of general and military vocabulary</td>
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</table>

| 853-0404-00L | French, Part II        | W    | 3 credits | 4G    | S. Schweizer |
|              | Only for Public Policy BA |      |       |       |           |
| Abstract     | Based on the knowledge and skills acquired during the first semester, speaking and discussion skills related to military situations are examined and put into practice. Attention is focused on issues such as instruction, qualification and career interviews. |
| Objective    | This two-semester French course should enable the German speaking participants to fulfil their function as professional officers also in the French language. |
| Content      | Read, analyse and write military and civilian documents |
|              | Listening comprehension using current radio or TV reports |
|              | Practise speaking with group discussions and short presentations |
|              | Systematic revision and extension of key grammar points |
|              | Systematic acquisition of general and military vocabulary |

Bachelor's Colloquium and Bachelor's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>853-0315-00L</td>
<td>BA Colloquium</td>
<td>O</td>
<td>2 credits</td>
<td>2K</td>
<td>F. Schimmelfennig</td>
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<tr>
<td></td>
<td>Only for BA Public Policy.</td>
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</tr>
<tr>
<td>Abstract</td>
<td>The BA Colloquium prepares students for their BA thesis with regard to content, administration, and methodology. During the colloquium, students choose a topic and a supervisor for their thesis. The skills students have acquired during the course of their studies are also enhanced and optimized.</td>
<td></td>
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<tr>
<td>Objective</td>
<td>The students are being prepared administratively and methodologically to write their BA-thesis after completing the course.</td>
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</tr>
<tr>
<td>Content</td>
<td>The BA Colloquium prepares students for their BA thesis with regard to content, administration, and methodology. During the colloquium, each student has to choose a topic for his/her BA-thesis. The students also choose their supervisors, whereas the goal is an even distribution of the supervisors. Finally, the methodological competences which were acquired during the first four semesters will be complemented.</td>
<td></td>
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</tbody>
</table>
853-0654-00L Bachelor's Thesis

<table>
<thead>
<tr>
<th>Objective</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The elaboration of the Bachelor Thesis should further students' capacities to work independently, structured and scientifically.</td>
<td>C. Herrmann</td>
</tr>
</tbody>
</table>

**Recommended Elective Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>853-8002-00L</td>
<td>The Role of Technology in National and International Security Policy</td>
<td>W+</td>
<td>3 credits</td>
<td>2G</td>
<td>O. Thränert, A. Dossi, S.-C. Fischer, M. Leese, N. Masuhr</td>
</tr>
</tbody>
</table>

**Additional Elective Courses**

<table>
<thead>
<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1033-00L</td>
<td>History of Sports</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Gisler</td>
</tr>
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<tr>
<td>376-1107-00L</td>
<td>Sport Pedagogy</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>C. Herrmann</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>376-1117-00L</td>
<td>Sport Psychology</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>H. Gubelmann, C. Baldasare Ackermann, P. Müller</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2124 of 2416
**Main Topics**
- Introduction to sport psychology
- Cognitions in sports: mental rehearsal and mental training
- Emotions and stress
- Motivation: goal-setting in sports
- Career and career transition in elite sport
- Coach-Athlete Interaction
- Psychological aspects of sport-injury rehabilitation
- Group dynamics in sport

**Lecture notes**
Instructional materials for each course will be made available to students. All lecture materials will be available to students on Moodle.

**Literature**


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**376-1127-00L Sociology of Sport**

**Abstract**
These lectures deal with the current changes in society and sport and provide an overview of the many different problems and perspectives of sport sociology.

**Objective**
The lectures set out to:
- present the different dimensions, functions and interrelationships of present-day sport
- provide an introduction to the central theories and models of (sport) sociology
- show how far sport reflects society and how it changes and becomes more differentiated in the process
- take current examples to highlight the sociological view of sport.

**Content**
Sport and social change: developments and trends
The economy and the media: dependencies, consequences, scandals
Social inequalities and distinctions: gender differences and group behavior
Conflicts and politics: sports organizations, doping, violence

**Lecture notes**
Selected materials for the lecture are available on the Moodle platform.

**Literature**

A detailed program with additional references will be delivered at the beginning of the lecture.

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories assessed
- Method-specific Competencies: Analytical Competencies assessed
- Social Competencies: Sensitivity to Diversity assessed
- Personal Competencies: Critical Thinking assessed

---

**851-0589-00L Technology and Innovation for Development**

**Abstract**
Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

**Objective**
- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

**Content**
Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies.

The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

**Lecture notes**
Reader with issue-specific articles. E-version is partly available on Moodle
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and...

**International Environmental Politics**

- **W 3 credits**
- **T. Bernauer**
- **Particularly suitable for students of D-ITET, D-USYS**

**Abstract**

This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

**Objective**

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

**Content**

This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

**Lecture notes**

- **Reading materials and slides will be available via Moodle.**

<table>
<thead>
<tr>
<th>Code</th>
<th>Course Title</th>
<th>W</th>
<th>G</th>
<th>T. Zagorac-Uremovic, D. Baschung, J. O'Neil</th>
</tr>
</thead>
<tbody>
<tr>
<td>363-0341-00L</td>
<td>Introduction to Management</td>
<td>3</td>
<td>2G</td>
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</tbody>
</table>

**Abstract**

This course is an introduction to the critical management skills involved in planning, organizing, leading and controlling an organization.
The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Particularly suitable for students of D-ITET, D-MAVT

<table>
<thead>
<tr>
<th>Objective</th>
<th>Content</th>
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<tbody>
<tr>
<td>- Analyze organizations as open systems, and describe their critical elements, - Apply conceptual tools and methods that help to analyze or approach the critical elements, - Compare different notions of organizational performance, and explain why they matter, - Discuss the relationships that connect the critical elements of an organization on the basis of real cases, - Explain how change, internally or externally initiated, impact such relationships</td>
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<table>
<thead>
<tr>
<th>Lecture notes</th>
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<tbody>
<tr>
<td>The content of the course will rely on different readings, cases and selected chapters of following book: Dess, G., McMamara, G., Eisner, A., &amp; Lee, SH. 2018. Strategic Management: Text and Cases. McGraw Hill. Selected readings from the book and additional learning materials will be available on the course Moodle: <a href="https://moodle-app2.let.ethz.ch/course/edit.php?id=17562">https://moodle-app2.let.ethz.ch/course/edit.php?id=17562</a></td>
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<thead>
<tr>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>The final exam is requested for all types of students (BSc, MSc, MA, PhD, and Exchange students). It is not possible to retake the exam within the same term or academic year. We strongly encourage Exchange students to take it into consideration when selecting the course to attend.</td>
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<table>
<thead>
<tr>
<th>Fostered competencies</th>
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<tr>
<td>Subject-specific Competencies</td>
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<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Personal Competencies</td>
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<td>Adaptability and Flexibility</td>
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<td>Creative Thinking</td>
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<td>Critical Thinking</td>
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<tr>
<td>Integrity and Work Ethics</td>
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<table>
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<tr>
<th>Literature</th>
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<tbody>
<tr>
<td>The content of the course will rely on different readings and on selected chapters of following book: Dess, G., McMamara, G., Eisner, A., &amp; Lee, SH. 2018. Strategic Management: Text and Cases. McGraw Hill. Selected readings from the book and additional learning materials will be available on the course Moodle: <a href="https://moodle-app2.let.ethz.ch/course/edit.php?id=17562">https://moodle-app2.let.ethz.ch/course/edit.php?id=17562</a></td>
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</table>

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<tr>
<th>Prerequisites / notice</th>
<th></th>
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<tbody>
<tr>
<td>Throughout the course different session preparation assignments, like reading book chapters or case studies will be handed out to the students on Moodle. This preparation is required to participate in the lectures.</td>
<td></td>
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<table>
<thead>
<tr>
<th>851-0735-10L</th>
<th>Law for Entrepreneurs</th>
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</thead>
<tbody>
<tr>
<td>Number of participants limited to 100</td>
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</table>

| Abstract | The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions. |
| Objective | The students shall obtain the following competence: - They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise. - They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution - They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed. - They shall be able to contribute to the legal management of the company and to discuss legal issues. - They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company. |
| Lecture notes | A comprehensive script will be made available online on the moodle platform. |

<table>
<thead>
<tr>
<th>101-0515-00L</th>
<th>Project Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.</td>
</tr>
<tr>
<td>Objective</td>
<td>Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company wide success.</td>
</tr>
<tr>
<td>Content</td>
<td>The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project. - Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.</td>
</tr>
<tr>
<td>Lecture notes</td>
<td>No. The lecture slides and other additional material will be available for download from Moodle a week before each class.</td>
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<table>
<thead>
<tr>
<th>701-0703-00L</th>
<th>Environmental Ethics</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.</td>
</tr>
<tr>
<td>Objective</td>
<td>On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.</td>
</tr>
<tr>
<td>Content</td>
<td>- Introduction to general and applied ethics. - Overview and discussion of ethical theories relevant to address environmental challenges. - Familiarization with various basic standpoints within environmental ethics. - Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc. - Practicing of newly acquired knowledge in smaller exercises.</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2127 of 2416
Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.

Literature:
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O’Neill et al., Environmental Values, 2006
- Konrad Ott/Juan Dierks/Lieske Vogel-Kliesch, Handbuch Umweltethik, 2016

General introductions:
- Barbara Bleisch/Markus Huppenbauer: Ethische Entscheidungsfindung, Ein Handbuch für die Praxis, Zürich 2014, 2. Auflage
- Marcus Düwell et. al (Hrsg.), Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006
- Johann S. Ach et. al (Hrsg.), Grundkurs Ethik 1. Grundlagen, Paderborn (mentis) 2008

Prerequisites / notice:
The procedure for accumulating CP will be explained at the start of term.
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

151-0757-00L Environmental Management W 2 credits 2G R. Züst

Abstract: An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

Objective: Overview on environmental management and environmental management systems, general methods and principles.

Content: Introduction to environmental management / environmental management systems, energy and material flows; economical and ecological problems in industry; characterisation of an enterprise (incl. management handbook); structure and contents of an environmental management system; overview on the ISO 14001 ff. series; methods for environmental evaluation and assessment; integrated management systems; planning methodology and life-cycle-design design; planning exampl

Lecture notes: Information about environmental management and environmental management systems will be provided by a CD or mail.

Literature: a list with literatures and links will be provided

Prerequisites / notice: Delivery of a case study, worked out in groups. Language: Teaching in English on request.

851-0180-00L Research Ethics W 2 credits 2G G. Aachermann, P. Emch

Abstract: Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective: Participants of the course Research Ethics will
• Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
• Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning

1. Ethics - the basics
1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity
1.5 Selection of study participants – the concept of vulnerability
1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media
2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!)
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).
3. What are the requirements?
4. What is the incidence of misconduct?
5. What are the factors that lead to misconduct?
6. Responding to research wrongdoing
7. The process of dealing with misconduct
8. Approaches to misconduct prevention and for promoting integrity in research
9. The ethics of big data
10. The ethics of big data

Fostered competencies

<table>
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<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tbody>
<tr>
<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Problem-solving</td>
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<td>Social Competencies</td>
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<td>Personal Competencies</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td></td>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Self-awareness and Self-reflection</td>
<td>assessed</td>
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</tbody>
</table>

851-0861-01L Arabic I A1.1
No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".


Registration dates: https://www.sprachzentrum.uzh.ch/en/Sprachkurse.html

Abstract
Arabic I leads to A1.1 level on the Common European Framework of Reference for Languages. Arabic I is the first part (A1.1 level) of a four-semester Arabic course. The goal of the course is for participants to acquire basic language skills in speaking, listening, comprehension, and the reading and writing of Arabic script.

Objective
Participants are able to use the Arabic language adequately in selected areas. The focus is on speaking; reading and listening comprehension at A1.1 level on the Common European Framework of Reference for Languages; learning Arabic script; and the development of cultural competence. The following content areas are embedded in various communicative tasks: Greeting each other, introducing yourself and speaking about yourself (personal and professional identity, place of residence), making simple phone calls, requesting information, and making appointments.
### Public Policy Bachelor - Key for Type

<table>
<thead>
<tr>
<th>Dr</th>
<th>Suitable for doctorate</th>
<th>W</th>
<th>Eligible for credits</th>
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<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
<td>Courses outside the curriculum</td>
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### Key for Hours

<table>
<thead>
<tr>
<th>V</th>
<th>lecture</th>
<th>P</th>
<th>practical/laboratory course</th>
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<tbody>
<tr>
<td>G</td>
<td>lecture with exercise</td>
<td>A</td>
<td>independent project</td>
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<td>U</td>
<td>exercise</td>
<td>D</td>
<td>diploma thesis</td>
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<tr>
<td>S</td>
<td>seminar</td>
<td>R</td>
<td>revision course / private study</td>
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<td>K</td>
<td>colloquium</td>
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**ECTS**

- European Credit Transfer and Accumulation System
- Special students and auditors need special permission from the lecturers.
Statistics Master

The following courses belong to the curriculum of the Master's Programme in Statistics. The corresponding credits do not count as external credits even for course units where an enrolment at ETH Zurich is not possible.

▶ Core Courses

★★ Statistical Modelling

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-3622-00L</td>
<td>Statistical Modelling</td>
<td>W</td>
<td>8 credits</td>
<td>4G</td>
<td>P. L. Bühlmann</td>
</tr>
</tbody>
</table>

Abstract
In regression, the dependency of a random response variable on other variables is examined. We consider the theory of linear regression with one or more covariates, high-dimensional linear models, nonlinear models and generalised linear models, robust methods, model choice and nonparametric models. Several numerical examples will illustrate the theory.

Objective
Introduction into theory and practice of a broad and popular area of statistics, from a modern viewpoint.

Content

Prerequisites / notice
Credits cannot be recognised for both courses 401-3622-00L Statistical Modelling and 401-0649-00L Applied Statistical Regression in the Mathematics Bachelor and Master programmes (to be precise: one course in the Bachelor and the other course in the Master is also forbidden).

<table>
<thead>
<tr>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td>401-4623-00L</td>
<td>Time Series Analysis</td>
<td>W</td>
<td>4 credits</td>
<td>2G</td>
<td>N. Meinshausen</td>
</tr>
</tbody>
</table>

Abstract
The course offers an introduction into analyzing times series, that is observations which occur in time. The material will cover Stationary Models, ARMA processes, Spectral Analysis, Forecasting, Nonstationary Models, ARIMA Models and an introduction to GARCH models.

Objective
The goal of the course is to have a good overview of the different types of time series and the approaches used in their statistical analysis.

Content
This course treats modeling and analysis of time series, that is random variables which change in time. As opposed to the i.i.d. framework, the main feature exhibited by time series is the dependence between successive observations.

The key topics which will be covered as:

- Stationarität
- Autokorrelation
- Trend estimation
- Elimination of seasonality
- Spectral analysis, spectral densities
- Forecasting
- ARMA, ARIMA, Introduction into GARCH models

Prerequisites / notice
Basic knowledge in probability and statistics

★★ Applied Statistics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power

Prerequisites / notice

★★ Mathematical Statistics

The two core courses Fundamentals of Mathematical Statistics (401-3621-00L) and Likelihood Inference (401-8623-00L) are similar in content. Therefore only one of them can be recognised towards the Master's degree in the core course area «Mathematical Statistics».

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3621-00L</td>
<td>Fundamentals of Mathematical Statistics</td>
<td>W</td>
<td>10 credits</td>
<td>4V+1U</td>
<td>S. van de Geer</td>
</tr>
</tbody>
</table>

Abstract
The course covers the basics of inferential statistics.

<table>
<thead>
<tr>
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<th>ECTS</th>
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<tbody>
<tr>
<td>401-8623-00L</td>
<td>Likelihood Inference (University of Zurich)</td>
<td>W</td>
<td>5 credits</td>
<td>3G</td>
<td>University lecturers</td>
</tr>
</tbody>
</table>

Abstract
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. UZH Module Code: STA402

Mind the enrolment deadlines at UZH: https://www.uzh.ch/cmsssl/en/studies/application/deadlines.html

Objective
Overview over the basics of likelihood inference.

★★ Subject Specific Electives

<table>
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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>401-3601-00L</td>
<td>Probability Theory</td>
<td>W</td>
<td>10 credits</td>
<td>4V+1U</td>
<td>W. Werner, D. Schröder</td>
</tr>
</tbody>
</table>

At most one of the three course units (Bachelor Core
Courses
401-3461-00L Functional Analysis I
401-3531-00L Differential Geometry I
401-3601-00L Probability Theory

can be recognised for the Master's degree in Mathematics or Applied Mathematics. In this case, you cannot change the category assignment by yourself in myStudies but must take contact with the Study Administration Office (www.math.ethz.ch/studiensekretariat) after having received the credits.

Moreover, 401-3601-00L Probability Theory can only be recognised for the Master Programme in Mathematics if neither 401-3642-00L Brownian Motion and Stochastic Calculus nor 401-3602-00L Applied Stochastic Processes has been recognised for the Bachelor Programme.

Abstract

Basics of probability theory and the theory of stochastic processes in discrete time

Objective

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

Basics in measure theory, series of independent random variables, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Content

This course presents the basics of probability theory and the theory of stochastic processes in discrete time. The following topics are planned:

Basics in measure theory, random series, law of large numbers, weak convergence, characteristic functions, central limit theorem, conditional expectation, martingales, convergence theorems for martingales, Galton Watson processes, Markov chains (classification and convergence results).

Lecture notes

will be available in electronic form.

Literature

H. Bauer, Probability Theory, de Gruyter 1996
J. Jacod and P. Protter, Probability essentials, Springer 2004
A. Klenke, Wahrscheinlichkeitstheorie, Springer 2006
D. Williams, Probability with martingales, Cambridge University Press 1991

401-3627-00L High-Dimensional Statistics

Abstract

"High-Dimensional Statistics" deals with modern methods and theory for statistical inference when the number of unknown parameters is of much larger order than sample size. Statistical estimation and algorithms for complex models and aspects of multiple testing will be discussed.

Objective

Knowledge of methods and basic theory for high-dimensional statistical inference

Content

Lasso and Group Lasso for high-dimensional linear and generalized linear models; Additive models and many smooth univariate functions; Non-convex loss functions and l1-regularization; Stability selection, multiple testing and construction of p-values; Undirected graphical modeling

Literature


Prerequisites / notice

Knowledge of basic concepts in probability theory, and intermediate knowledge of statistics (e.g. a course in linear models or computational statistics).

401-3612-00L Stochastic Simulation

Abstract

This course provides an introduction to statistical Monte Carlo methods. This includes applications of simulations in various fields (Bayesian statistics, statistical mechanics, operations research, financial mathematics), algorithms for the generation of random variables (accept-reject, importance sampling), estimating the precision, variance reduction, introduction to Markov chain Monte Carlo.

Objective

Stochastic simulation (also called Monte Carlo method) is the experimental analysis of a stochastic model by implementing it on a computer. Probabilities and expected values can be approximated by averaging simulated values, and the central limit theorem gives an estimate of the error of this approximation. The course shows examples of the many applications of stochastic simulation and explains different algorithms used for simulation. These algorithms are illustrated with the statistical software R.

Content


Lecture notes

A script will be available in English.

Literature


Prerequisites / notice

Familiarity with basic concepts of probability theory (random variables, joint and conditional distributions, laws of large numbers and central limit theorem) will be assumed.

401-4633-00L Data Analytics in Organisations and Business

Abstract

This lecture covers organizations and businesses' end-to-end data analytics process and deepens each process stage. It shows why a stage is needed and what actions are taken in each stage. It gives steps successfully applied in practice and loopholes when issues arise. Case studies from various industries will be presented for each stage.

Objective

This course aims to give the students an understanding of the whole data analytics life cycle in the business world. It shows the expectations of companies and how it is measured. It enables the student to manage successfully all the non-methodological aspects of a data analytics project which are the primary source of failure in end-to-end executions. The student will become familiar with the "business language, and cultural aspects of organizations. It also gives an overview of the data analytics tool, platform, and methods ecosystem for successfully technical data analyses.
The students will be able to use the software R efficiently for data analysis, graphics and simple programming.

The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course builds on part I and covers the following additional topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options;
- Extending basic R: packages;
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The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org.

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### 401-3628-14L Bayesian Statistics

**Objective**

Students understand the conceptual ideas behind Bayesian statistics and are familiar with common techniques used in Bayesian data analysis.

**Content**

Topics that will discuss are:

- Difference between the frequentist and Bayesian approach (decision theory, principles), priors (conjugate priors, noninformative priors, Jeffreys prior), tests and model selection (Bayes factors, hyper-g priors for regression), hierarchical models and empirical Bayes methods, computational methods (Laplace approximation, Monte Carlo and Markov chain Monte Carlo methods).

**Lecture notes**

Introduction to the statistical methods of survey research

**Literature**


Additional references will be given in the course.

### 401-3901-00L Linear & Combinatorial Optimization

**Objective**

The goal of this course is to get a thorough understanding of various classical mathematical optimization techniques for linear and combinatorial optimization problems, with an emphasis on polyhedral approaches. In particular, we want students to develop a good understanding of some important problem classes in the field, of structural mathematical results linked to these problems, and of solution approaches based on such structural insights.

**Content**

Key topics include:

- Linear programming and polyhedra;
- Flows and cuts;
- Combinatorial optimization problems and polyhedral techniques;
- Equivalence between optimization and separation.

**Literature**


**Prerequisites / notice**

Solid background in linear algebra.

### 401-4944-20L Mathematics of Data Science

**Objective**

Introduction to various mathematical aspects of Data Science.

**Content**

These topics lie in overlaps of (Applied) Mathematics with: Computer Science, Electrical Engineering, Statistics, and/or Operations Research. Each lecture will feature a couple of Mathematical Open Problem(s) related to Data Science. The main mathematical tools used will be Probability and Linear Algebra, and a basic familiarity with these subjects is required. There will also be some (although knowledge of these tools is not assumed) Graph Theory, Representation Theory, Applied Harmonic Analysis, among others. The topics treated will include Dimension reduction, Manifold learning, Sparse recovery, Random Matrices, Approximation Algorithms, Community detection in graphs, and several others.

**Lecture notes**

Prerequisites / notice

The main mathematical tools used will be Probability, Linear Algebra (and real analysis), and a working knowledge of these subjects is required. In addition to these prerequisites, this class requires a certain degree of mathematical maturity—including abstract thinking and the ability to understand and write proofs.

We encourage students who are interested in mathematical data science to take both this course and "227-0434-10L Mathematics of Information" taught by Prof. H. Bölcskei. The two courses are designed to be complementary.

A. Bandeira and H. Bölcskei

252-0535-00L Advanced Machine Learning

Abstract

Machine learning algorithms provide analytical methods to search data sets for characteristic patterns. Typical tasks include the classification of data, function fitting and clustering, with applications in image and speech analysis, bioinformatics and exploratory data analysis. This course is accompanied by practical machine learning projects.

Objective

Students will be familiarized with advanced concepts and algorithms for supervised and unsupervised learning; reinforce the statistics knowledge which is indispensable to solve modeling problems under uncertainty. Key concepts are the generalization ability of algorithms and systematic approaches to modeling and regularization. Machine learning projects will provide an opportunity to test the machine learning algorithms on real world data.

Content

The theory of fundamental machine learning concepts is presented in the lecture, and illustrated with relevant applications. Students can deepen their understanding by solving both pen-and-paper and programming exercises, where they implement and apply famous algorithms to real-world data.

Topics covered in the lecture include:

- Fundamentals:
  - What is data?
  - Bayesian Learning
  - Computational learning theory
- Supervised learning:
  - Ensembles: Bagging and Boosting
  - Max Margin methods
  - Neural networks
- Unsupervised learning:
  - Dimensionality reduction techniques
  - Clustering
  - Mixture Models
  - Non-parametric density estimation
  - Learning Dynamical Systems

Lecture notes

No lecture notes, but slides will be made available on the course webpage.

Literature


252-3005-00L Natural Language Processing

Abstract

This course presents topics in natural language processing with an emphasis on modern techniques, primarily focusing on statistical and deep learning approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Objective

The objective of the course is to learn the basic concepts in the statistical processing of natural languages. The course will be project-oriented so that the students can also gain hands-on experience with state-of-the-art tools and techniques.

Content

This course presents an introduction to general topics and techniques used in natural language processing today, primarily focusing on statistical approaches. The course provides an overview of the primary areas of research in language processing as well as a detailed exploration of the models and techniques used both in research and in commercial natural language systems.

Literature

Lectures will make use of textbooks such as the one by Jurafsky and Martin where appropriate, but will also make use of original research and survey papers.

Prerequisites / notice

The course requires solid basic knowledge in analysis, statistics and numerical methods for CSE as well as practical programming experience for solving assignments. Students should have followed at least "Introduction to Machine Learning" or an equivalent course offered by another institution.

PhD students are required to obtain a passing grade in the course (4.0 or higher based on project and exam) to gain credit points.

227-0423-00L Neural Network Theory

Does not take place this semester.

Abstract

The class focuses on fundamental mathematical aspects of neural networks with an emphasis on deep networks: Universal approximation theorems, capacity of separating surfaces, generalization, fundamental limits of deep neural network learning, VC dimension.

Objective

After attending this lecture, participating in the exercise sessions, and working on the homework problem sets, students will have acquired a working knowledge of the mathematical foundations of neural networks.
1. Universal approximation with single- and multi-layer networks
2. Introduction to approximation theory: Fundamental limits on compressibility of signal classes, Kolmogorov epsilon-entropy of signal classes, non-linear approximation theory
3. Fundamental limits of deep neural network learning
4. Geometry of decision surfaces
5. Separating capacity of nonlinear decision surfaces
6. Vapnik-Chervonenkis (VC) dimension
7. VC dimension of neural networks
8. Generalization error in neural network learning

### Contents
- **Abstract**: A range of topics will be covered, including basic molecular biology, genomics technologies and in particular, a wide range of statistical and computational methods that have been used in the analysis of DNA microarray and high throughput sequencing experiments.
- **Objective**: To gain an understanding of the fundamental "scientific process" in the field of Statistical Bioinformatics.
- **Content**: Lectures will include: microarray preprocessing; normalization; exploratory data analysis techniques such as clustering, PCA and multidimensional scaling; Controlling error rates of statistical tests (FPR versus FDR versus FWER); limma (linear models for microarray analysis); mapping algorithms (for RNA/ChIP-seq); RNA-seq quantification; statistical analyses for differential count data; isoform switching; epigenomics data including DNA methylation; gene set analyses; classification
- **Prerequisites / notice**: Prerequisites: Basic knowledge of the programming language R, sufficient knowledge in statistics

### Lectures
- **Lecture notes**: Detailed lecture notes are available on the course web page [https://www.mins.ee.ethz.ch/teaching/intl/](https://www.mins.ee.ethz.ch/teaching/intl/)

### Literature

### Notice
- No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.
- Mind the enrolment deadlines at UZH: [https://www.uzh.ch/cmsssl/en/studies/application/deadline.html](https://www.uzh.ch/cmsssl/en/studies/application/deadline.html)

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### Course: Statistical Analysis of High-Throughput Genomic and Transcriptional Data (University of Zurich)

**Course Code**: STA404
**Credits**: 6
**Semester**: Autumn Semester 2022
**Instructors**: N. Perraudin, F. Perez Cruz

**Content**
- Discussion of the different statistical methods that are used in clinical research.
- Among other subjects the following will be introduced: sample size calculation, randomization and blinding, analysis of clinical trials (parallel groups design, analysis of covariance, crossover design, equivalence studies), intention-to-treat analysis, multiple testing, group sequential methods, adaptive designs, diagnostic studies, and agreement studies.

**Prerequisites**
- Basic knowledge of the programming language R, sufficient knowledge in calculus, linear algebra, probability, statistics

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### Course: Clinical Biostatistics (University of Zurich)

**Course Code**: STA404
**Credits**: 5
**Semester**: Autumn Semester 2022
**Instructors**: H. Rehrauer, M. Robinson

**Content**
- Discussion of the different statistical methods that are used in clinical research.
- Introduction: sample size calculation, randomization and blinding, analysis of clinical trials (parallel groups design, analysis of covariance, crossover design, equivalence studies), intention-to-treat analysis, multiple testing, group sequential methods, adaptive designs, diagnostic studies, and agreement studies.

**Prerequisites / notice**
- Basic knowledge of the programming language R, sufficient knowledge in statistics

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### Course: Deep Learning

**Course Code**: STA404
**Credits**: 6
**Semester**: Autumn Semester 2022
**Instructors**: T. Hofmann, F. Perez Cruz, N. Perraudin

**Abstract**
- Deep learning is an area within machine learning that deals with algorithms and models that automatically induce multi-level data representations.

**Objective**
- In recent years, deep learning and deep networks have significantly improved the state-of-the-art in many application domains such as computer vision, speech recognition, and natural language processing. This class will cover the mathematical foundations of deep learning and provide insights into model design, training, and validation. The main objective is a profound understanding of why these methods work and how. There will also be a rich set of hands-on tasks and practical projects to familiarize students with this emerging technology.
This course introduces core modeling techniques and algorithms from machine learning, optimization and control for reasoning and decision making under uncertainty, and study applications in areas such as robotics.

The participation in the course is subject to the following condition:
- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustivelist below:
  - Advanced Machine Learning
    https://ml2.inf.ethz.ch/courses/aml/
  - Computational Intelligence Lab
    http://da.inf.ethz.ch/teaching/2019/CIL/
  - Introduction to Machine Learning
    https://las.inf.ethz.ch/teaching/introml-S19
  - Statistical Learning Theory
    http://ml2.inf.ethz.ch/courses/slt/
  - Computational Statistics
    https://stat.ethz.ch/lectures/ss19/comp-stats.php
  - Probabilistic Artificial Intelligence
    https://las.inf.ethz.ch/teaching/pai-f18

### Prerequisites / notice

This is an advanced level course that requires some basic background in machine learning. More importantly, students are expected to have a very solid mathematical foundation, including linear algebra, multivariate calculus, and probability. The course will make heavy use of mathematics and is not (!) meant to be an extended tutorial of how to train deep networks with tools like Torch or Tensorflow, although that may be a side benefit.

The participation in the course is subject to the following condition:

- Students must have taken the exam in Advanced Machine Learning (252-0535-00) or have acquired equivalent knowledge, see exhaustivelist below:

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<tr>
<td>263-5210-00L Probabilistic Artificial Intelligence</td>
<td>W 8 credits</td>
<td>Solid basic knowledge in statistics, algorithms and programming. The material covered in the course “Introduction to Machine Learning” is considered as a prerequisite.</td>
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<tr>
<td>263-5300-00L Guarantees for Machine Learning</td>
<td>W 7 credits</td>
<td>Number of participants limited to 30.</td>
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The project work focuses on current theoretical ML research that aims to understand modern phenomena in machine learning, including but not limited to:
- how overparameterized models generalize (statistically) and converge (computationally)
- complexity measures and approximation theoretic properties of randomly initialized and trained neural networks
- generalization of robust learning (adversarial or distribution-shift robustness)
- private and fair learning

### Prerequisites / notice

Students should have a very strong background in scientific computing, including knowledge of linear algebra and probability. Students should have a very strong background in scientific computing, including knowledge of linear algebra and probability. Students should have a very strong background in scientific computing, including knowledge of linear algebra and probability. Students should have a very strong background in scientific computing, including knowledge of linear algebra and probability.
Reliable and Trustworthy Artificial Intelligence

Abstract
Creating reliable, secure, robust, and fair machine learning models is a core challenge in artificial intelligence and one of fundamental importance. The goal of the course is to teach both the mathematical foundations of this new and emerging area as well as to introduce students to the latest and most exciting research in the space.

Objective
Upon completion of the course, the students should have mastered the underlying methods and be able to apply them to a variety of engineering and research problems. To facilitate deeper understanding, the course includes a group coding project where students will build a system based on the learned material.

Content
The course is split into 3 parts:

- Adversarial attacks and defenses on deep learning models.
- Automated certification of deep learning models (covering the major trends: convex relaxations and branch-and-bound methods as well as randomized smoothing).
- Certified training of deep neural networks to satisfy given properties (combining symbolic and continuous methods).

Privacy of Machine Learning

- Threat models (e.g., stealing data, poisoning, membership inference, etc.).
- Attacking federated machine learning (across modalities such as vision, natural language and tabular).
- Differential privacy for defending machine learning.
- Enforcing regulations with guarantees (e.g., via provable data minimization).

Fairness of Machine Learning

- Introduction to fairness (motivation, definitions).
- Enforcing individual fairness with guarantees (e.g., for both vision or tabular data).
- Enforcing group fairness with guarantees.

Prerequisites / notice
While not a formal requirement, the course assumes familiarity with basics of machine learning (especially linear algebra, gradient descent, and neural networks as well as basic probability theory). These topics are usually covered in "Intro to ML" classes at most institutions (e.g., "Introduction to Machine Learning" at ETH).

For solving assignments, some programming experience in Python is expected.

Seminar or Semester Paper

Number Title Type ECTS Hours Lecturers
401-3620-20L Student Seminar in Statistics: Inference in Some Non-Standard Regression Problems W 4 credits 2S F. Balabdaoui

Number of participants limited to 24.
Mainly for students from the Mathematics Bachelor and Master Programmes who, in addition to the introductory course unit 401-2604-00L Probability and Statistics, have heard at least one core or elective course in statistics.
Also offered in the Master Programmes Statistics resp. Data Science.

Abstract
Review of some non-standard regression models and the statistical properties of estimation methods in such models.

Objective
The main goal is the students get to discover some less known regression models which either generalize the well-known linear model (for example monotone regression) or violate some of the most fundamental assumptions (as in shuffled or unlinked regression models).

Content
Linear regression is one of the most used models for prediction and hence one of the most understood in statistical literature. However, linearity might be too simplistic to capture the actual relationship between some response and given covariates. Also, there are many real data problems where linearity is plausible but the actual pairing between the observed covariates and responses is completely lost or at partially. In this seminar, we review some of the non-classical regression models and the statistical properties of the estimation methods considered by well-known statisticians and machine learners. This will encompass:
1. Monotone regression
2. Single index model
3. Unlinked regression
Supervisors

In the following is the tentative material that will be read and studied by each pair of students (all the items listed below are available through the ETH electronic library or arXiv). Some of the items might change.


8. "Linear regression with shuffled data: statistical and computation limits of permutation recovery" by A. Pananjady, M. Wainwright and T. A. Courtade, 2018, IEEE transactions in Information Theory, Volume 64, 3286-3300

9. "Linear regression without correspondence" by D. Hsu, K. Shi and X. Sun, 2017, NIPS


11. "Uncoupled isotonic regression via minimum Wasserstein deconvolution" by P. Rigollet and J. Weed, 2019, Information and Inference, Volume 00, 1-27

Prerequisites / notice

The students need to be comfortable with regression models, classical estimation methods (Least squares, Maximum Likelihood estimation...), rates of convergence, asymptotic normality, etc.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites</th>
<th>Supervisor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-3630-04L</td>
<td>Semester Paper</td>
<td>4 credits</td>
<td>Successful participation in the course unit 401-2000-00L. Scientific Works in Mathematics is required. For more information, see <a href="http://www.math.ethz.ch/intranet/students/study-administration/theses.html">www.math.ethz.ch/intranet/students/study-administration/theses.html</a></td>
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</tr>
<tr>
<td>401-3630-06L</td>
<td>Semester Paper</td>
<td>6 credits</td>
<td>Successful participation in the course unit 401-2000-00L. Scientific Works in Mathematics is required. For more information, see <a href="http://www.math.ethz.ch/intranet/students/study-administration/theses.html">www.math.ethz.ch/intranet/students/study-administration/theses.html</a></td>
<td>Supervisors</td>
</tr>
<tr>
<td>252-5051-00L</td>
<td>Advanced Topics in Machine Learning</td>
<td>2 credits</td>
<td>Number of participants limited to 40.</td>
<td>J. M. Buhmann, R. Cotterell, N. He, F. Yang, M. Elassady</td>
</tr>
</tbody>
</table>

Abstract

Semester papers serve to delve into a problem in statistics and to study it with the appropriate methods or to compile and clearly exhibit a case study of a statistical evaluation.

Abstract

Semester papers serve to delve into a problem in statistics and to study it with the appropriate methods or to compile and clearly exhibit a case study of a statistical evaluation.

Abstract

The seminar "Advanced Topics in Machine Learning" familiarizes students with recent developments in pattern recognition and machine learning. Original articles have to be presented and critically reviewed. The students will learn how to structure a scientific presentation in English which covers the key ideas of a scientific paper. An important goal of the seminar presentation is to summarize the essential ideas of the paper in sufficient depth while omitting details which are not essential for the understanding of the work. The presentation style will play an important role and should reach the level of professional scientific presentations.

Content

The seminar will cover a number of recent papers which have emerged as important contributions to the pattern recognition and machine learning literature. The topics will vary from year to year but they are centered on methodological issues in machine learning like new learning algorithms, ensemble methods or new statistical models for machine learning applications. Frequently, papers are selected from computer vision or bioinformatics - two fields, which relies more and more on machine learning methodology and statistical models.

Literature

The papers will be presented in the first session of the seminar.

Free Electives

Several further courses offered at the University of Zurich belong to the curriculum of the Master's Programme in Statistics. With the consent by the Advisor (http://stat.ethz.ch/~kalisch/) such a course is eligible as a free elective.

Course Catalogue

Science in Perspective

Two credits are needed from the "Science in Perspective" programme with language courses excluded if three credits from language courses have already been recognised for the Bachelor's degree. see https://ethz.ch/content/dam/ethz/common/docs/leistungssammlung/files-en/science-in-perspective.pdf (Eight credits must be acquired in this category: normally six during the Bachelor's degree programme, and two during the Master's degree programme. A maximum of three credits from language courses from the range of the Language Center of the University of Zurich and ETH Zurich may be recognised. In addition, only advanced courses (level B2 upwards) in the European languages English, French, Italian and Spanish are recognised. German language courses are recognised from level C2 upwards.) see Science in Perspective: Type A: Enhancement of Reflection Capability
### Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
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<tr>
<td>401-2000-00L</td>
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<td>O</td>
<td>0</td>
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<td>D. Possamaï</td>
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<td><strong>Target audience:</strong></td>
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<td>Third year Bachelor students;</td>
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<td>scientifically.</td>
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<td>Introduction to scientific writing for students</td>
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<td>with focus on publication standards and ethical</td>
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<td>issues, especially in the case of citations</td>
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<td>(references to works of others.)</td>
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<td>Learn the basic standards of scientific works</td>
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<td>in mathematics.</td>
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<td><strong>Content</strong></td>
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<td>- Types of mathematical works</td>
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<td>- Publication standards in pure and applied</td>
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<td>- Ethical issues</td>
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<td>- Citation guidelines</td>
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<th>Lecturers</th>
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<td>Lunch Sessions – Thesis Basics for Mathematics</td>
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<td><strong>Students</strong></td>
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<td>Optional MathBib training course</td>
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<td>401-4990-02L</td>
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<td>57D</td>
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<td>begin with their Master's thesis:**</td>
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<td>a. successful completion of the Bachelor's programme;</td>
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<td>b. fulfilling of any additional requirements necessary to</td>
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<td>gain admission to the Master's programme;</td>
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<td>c. They have acquired at least 16 credits in the category</td>
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<td>&quot;Core courses&quot; for Programme Regulations 2014 and 40</td>
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<td>credits in the category &quot;Main Areas&quot; for Programme Regulations 2020.</td>
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<td><strong>Successful participation in the course unit 401-2000-00L</strong></td>
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<td>Scientific Works in Mathematics is required.</td>
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<td>For more information, see</td>
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<td><a href="http://www.math.ethz.ch/intranet/students/study-administration/theses.html">www.math.ethz.ch/intranet/students/study-administration/theses.html</a></td>
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<tr>
<td></td>
<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>The master's thesis concludes the study programme. Thesis work should prove the students' ability to independent, structured and scientific working.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>Thesis work should prove the students' ability to independent, structured and scientific working.</td>
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<td><strong>Content</strong></td>
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<td></td>
<td>Five-month project to solve a research question. The content can be more theoretical (e.g. proving a new result) or applied (developing new methods or making a very sophisticated application and adapting existing methods).</td>
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<td><strong>Prerequisites / notice</strong></td>
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<td></td>
<td>Supervisors are chosen on a first-come-first-served basis. Collaborations with industry are possible.</td>
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</tbody>
</table>

### Course Units for Additional Admission Requirements

The courses below are only available for MSc students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>406-0173-AAL</td>
<td>Linear Algebra I and II</td>
<td>E-</td>
<td>6</td>
<td>13R</td>
<td>N. Hungerbühler</td>
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<tr>
<td></td>
<td><strong>Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.</strong></td>
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<tr>
<td></td>
<td>Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.</td>
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<td><strong>Abstract</strong></td>
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<tr>
<td></td>
<td>Linear algebra is an indispensable tool of engineering mathematics. The course is an introduction to basic methods and fundamental concepts of linear algebra and its applications to engineering sciences.</td>
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<td><strong>Objective</strong></td>
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<td></td>
<td>After completion of this course, students are able to recognize linear structures and to apply adequate tools from linear algebra in order to solve corresponding problems from theory and applications. In addition, students have a basic knowledge of the software package Matlab.</td>
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<tr>
<td></td>
<td><strong>Content</strong></td>
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<tr>
<td></td>
<td>Linear maps, kernel and image, coordinates and matrices, coordinate transformations, norm of a matrix, orthogonal matrices, eigenvalues and eigenvectors, algebraic and geometric multiplicity, eigenbasis, diagonalizable matrices, symmetric matrices, orthonormal basis, condition number, linear differential equations, Jordan decomposition, singular value decomposition, examples in MATLAB, applications.</td>
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<td><strong>Reading:</strong></td>
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<tr>
<td></td>
<td>Gilbert Strang “Introduction to linear algebra”, Wellesley-Cambridge Press: Chapters 1-6, 7.1-7.3, 8.1, 8.2, 8.6</td>
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</table>
**Abstract**

Mathematical tools for the engineer

**Objective**

Mathematics as a tool to solve engineering problems. Basic mathematical knowledge for engineers.

**Content**

Complex numbers. Calculus for functions of one variable with applications. Simple Mathematical models in engineering.


**Literature**

Textbooks in English:

Textbooks in German:
- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

---

**Abstract**

Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

**Objective**

The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

**Content**

From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

**Literature**

"Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435

From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435


From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

**Fostered competencies**

Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Media and Digital Technologies, Problem-solving, Self-direction and Self-management

Method-specific Competencies: assessed

Personal Competencies: assessed

---

**Abstract**

Introduction to probability and statistics with many examples, based on chapters from the books "Probability and Random Processes" by G. Grimmett and D. Stirzaker and "Mathematical Statistics and Data Analysis" by J. Rice.

**Objective**

The goal of this course is to provide an introduction to the basic ideas and concepts from probability theory and mathematical statistics. In addition to a mathematically rigorous treatment, also an intuitive understanding and familiarity with the ideas behind the definitions are emphasized. Measure theory is not used systematically, but it should become clear why and where measure theory is needed.
Content

Probability:
Chapters 1-5 (Probabilities and events, Discrete and continuous random variables, Generating functions) and Sections 7.1-7.5 (Convergence of random variables) from the book "Probability and Random Processes". Most of this material is also covered in Chap. 1-5 of "Mathematical Statistics and Data Analysis"; on a slightly easier level.

Statistics:
Sections 8.1 - 8.5 (Estimation of parameters), 9.1 - 9.4 (Testing Hypotheses), 11.1 - 11.3 (Comparing two samples) from "Mathematical Statistics and Data Analysis".

Literature

Geoffrey Grimmett and David Stirzaker, Probability and Random Processes.

John A. Rice, Mathematical Statistics and Data Analysis, 3rd edition.

<table>
<thead>
<tr>
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<th>Dr</th>
<th>W+</th>
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<tr>
<td>Compulsory</td>
<td>W</td>
<td>E-</td>
<td>Z</td>
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<tr>
<td>Suitable for doctorate</td>
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<td>Eligible for credits and recommended</td>
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ECTS

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
First Year Examinations

First Year Examination Block A

<table>
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<tr>
<th>Number</th>
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<td>3V+1U</td>
<td>M. Akka Ginosar</td>
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<td>Introduction to Linear Algebra</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>Basic knowledge of linear algebra as a tool for solving engineering problems. Understanding of abstract mathematical formulation of technical and scientific problems. Together with Analysis we develop the basic mathematical knowledge for an engineer.</td>
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<tr>
<td></td>
<td>Content</td>
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<td>The Modelling competency is taught, applied, and tested, and the Programming competency is applied. Introduction and linear systems of equations, matrices, quadratic matrices, determinants and traces, general vector spaces, linear mappings, bases, change of basis, diagonalization, eigenvalues and eigenvectors, orthogonal transformations, scalar-product, inner product spaces.</td>
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<td>Lecture notes</td>
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<td>Literature</td>
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<td>The lecturer will provide course notes.</td>
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<td>252-0845-00L</td>
<td>Computer Science I</td>
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<td>2V+2U</td>
<td>C. Cotrini Jimenez, M. Fischer</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>The course covers the basic concepts of computer programming.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Basic understanding of programming concepts. Students will be able to write and read simple programs and to modify existing programs. In the course &quot;Computer Science I&quot;, the competency of programming is taught, applied and examined. Furthermore modeling is taught and applied.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>variables, types, control structures, functions, scoping, recursion, object-oriented programming. The programming language is Python. Calculation with MATLAB will be introduced in the first exercise class.</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
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<td></td>
<td>The slides and lecture notes will be made available for download on the course website.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>Learn to Code by Solving Problems</td>
</tr>
<tr>
<td>701-0243-01L</td>
<td>Biology III: Essentials of Ecology</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>C. Buser Moser</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented. A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.</td>
</tr>
<tr>
<td></td>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td>- Einfluss von Umweltfaktoren (Temperatur, Strahlung, Wasser, Nährstoffe etc.) auf Organismen; Anpassung an bestimmte Umweltbedingungen</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
<td>- Populationsdynamik: Ursachen, Beschreibung, Vorhersage und Regulation</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>- Interaktionen zwischen Arten (Konkurrenz, Koexistenz, Prädation, Parasitismus, Nahrungsnetze)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Lebensgemeinschaften: Struktur, Stabilität, Sukzession</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>- Ökosysteme: Kompartimente, Stoff- und Energieflüsse</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>- Biodiversität: Variation, Ursachen, Gefährdung und Erhaltung</td>
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<td></td>
<td></td>
<td></td>
<td>- Aktuelle Naturschutzprobleme und -massnahmen</td>
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<td></td>
<td></td>
<td></td>
<td>- Evolutionäre Ökologie: Methodik, Spezialisierung, Koevolution</td>
</tr>
<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>Unterlagen, Vorlesungsfolien und relevante Literatur sind in Moodle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils spätestens am Freitagmorgen zur Verfügung.</td>
</tr>
<tr>
<td>151-0223-10L</td>
<td>Engineering Mechanics</td>
<td>O</td>
<td>4</td>
<td>2V+2U+1K</td>
<td>P. Tiso</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td></td>
<td></td>
<td></td>
<td>Introduction to engineering mechanics: kinematics, statics and dynamics of rigid bodies and systems of rigid bodies.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
<td></td>
<td></td>
<td></td>
<td>Students can solve problems of elementary engineering mechanics.</td>
</tr>
</tbody>
</table>
Content
Basic notions: position and velocity of particles, rigid bodies, planar motion, kinematics of rigid body, force, couple, power. Statics: static equivalence, force-couple system, center of forces, centroid, principle of virtual power, equilibrium, constraints, statics, friction. Dynamics: acceleration, inertial forces, d'Alembert's Principle, Newton's Second Law, principles of linear and angular momentum, equations of planar motion of rigid bodies.

Lecture notes
yes, in German

Literature
**Additional First Year Courses**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0004-00L</td>
<td>Introduction into Environmental Engineering</td>
<td>O</td>
<td>3</td>
<td>2</td>
<td>P. Molnar, P. Burlando, I. Hajnsek, S. Hellweg, M. Maurer, E. Morgenroth, K. Sperger, R. Stocker, J. Wang</td>
</tr>
</tbody>
</table>

**Abstract**

In this course students are introduced to how environmental problems in the areas of water quantity and quality, waste production and recycling, air pollution control, are formulated and solved with engineering methods. The course makes a connection between the theoretical Bachelor foundation classes and practical topics of environmental engineering in six main thematic areas.

**Objective**

- formulate key global environmental problems
- develop a systems perspective and solutions to the problems (critical thinking)
- identify and solve simple numerical problems in the domain areas
- understand why/how we use data/models in environmental engineering
- develop own interest in the domain areas and see career opportunities

**Content**

Topics of study:
1. Water Science & Engineering – definition of the global water cycle and hydrological regimes, surface/subsurface flow equations (advection, diffusion), water resources management, climate change.
4. River and Hydraulic Engineering – hydropower production, flood protection, river restoration, ecological measures at hydropower plants.
5. Air Quality – air quality parameters, main air pollutants, air quality in cities/indoor, emission control, the plume dispersion model.
6. Earth Observation – satellite observation of the Earth System from space, methods, environmental applications (glaciers, forest, land surface change)

**Lecture notes**

Course will take place in English and German (bilingual). The English textbook by Masters and Ela (see below) will be complemented by instructors materials to the individual thematic topics. Lecture presentations will be the main study material. There is no formal Script.

**Literature**

- lecture presentations and selected papers

**Bachelor Studies (Programme Regulations 2010)**

**1. Semester**

**First Year Examinations (1. Sem.)**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0031-01L</td>
<td>Systems Engineering</td>
<td>O</td>
<td>4</td>
<td>4</td>
<td>B. T. Adey</td>
</tr>
</tbody>
</table>
Geology and Petrography

This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups.
Objective
This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts.

Content

Übungen zum Gesteinsbestimmen und Lesen von geologischen, tektonischen und geotechnischen Karten, einfache Konstruktionen.

Lecture notes
Weekly handouts of PPT slides via MyStudies

Literature
The course is based on Press & Siever book Dynamic Earth by Grotzinger et al., available to ETH students via https://link.springer.com/book/10.1007/978-3-662-48342-8

3. Semester
Compulsory Courses 3. Semester
Examination Block 1

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>402-0023-01L</td>
<td>Physics</td>
<td>O</td>
<td>7 credits</td>
<td>5V+2U</td>
<td>S. Johnson</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course gives an overview of important concepts in classical dynamics, thermodynamics, electromagnetism, quantum physics, atomic physics, and special relativity. Emphasis is placed on demonstrating key phenomena using experiments, and in developing skills for quantitative problem solving.</td>
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<tr>
<td>Objective</td>
<td>The goal of this course is to make students able to explain and apply the basic principles and methodology of physics to problems of interest in modern science and engineering. An important component of this is learning how to solve new, complex problems by breaking them down into parts and applying simplifications. A secondary goal is to provide to students an overview of important subjects in both classical and modern physics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content</td>
<td>Electrodynamics, Thermodynamics, Quantum physics, Waves and Oscillations, special relativity</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture notes and exercise sheets will be distributed via Moodle</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

101-0203-01L   | Hydraulics I                         | O    | 5 credits | 3V+1U    | R. Stocker  |
| Abstract       | The course teaches the basics of hydromechanics, relevant for civil and environmental engineers. |
| Objective      | In the course "Hydraulics I", the competency of process understanding is taught, applied and examined. Furthermore system understanding and measurement methods are taught. |
| Content        | Properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids vs. real fluids, boundary layer, pipe flow, open channel flow, flow measurements, demonstration experiments in the lecture hall |
| Lecture notes  | Script and collection of previous problems |
| Literature     | Bolirch, Technische Hydromechanik 1, Verlag Bauwesen, Berlin |

103-0233-01L   | GIS I (for Environmental Engineers) | O    | 3 credits | 2G      | P. Kiefer  |
| Abstract       | Fundamentals of geoinformation technologies: spatial data modeling, metrics & topology, vector and raster data, thematic data, spatial queries and analysis, spatial databases; lab sessions with GIS software |
| Objective      | Knowing the fundamentals of geoinformation technologies for the realization, application and operation of geographic information systems in engineering projects. |
| Content        | Einführung GIS & GIScience
- Konzeptionelles Modell & Datenschema
- Vektorgeometrie & Topologie
- Rastergeometrie und -algebra
- Thematische Daten
- Räumliche Abarbeiten & Analysen |
| Lecture notes  | Vortragspräsentationen werden digital zur Verfügung gestellt. |

102-0293-00L   | Hydrology                           | O    | 3 credits | 2G      | P. Burlando|

Data: 01.11.2022 12:41       Autumn Semester 2022       Page 2147 of 2416
Abstract
The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the runoff transformation, thereby including flood analysis.

Objective
Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.

Content
The hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

Preliminary: measurement and estimation.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton’s equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnum surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – baseflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rationale, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Snow (and ice) hydrology: snow characteristic variables and measurements, estimation of snowmelt processes by the energy budget equation and conceptual melt models (temperature index method and degree-day method), snowmelt runoff.

Lecture notes
The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.

Literature

Prerequisites / notice
Knowledge of statistics is a prerequisite. The required theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:
- Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters), frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

701-0243-01L
Biology III: Essentials of Ecology

Abstract
This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.

Objective
The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented.

Content
- Einfluss von Umweltfaktoren (Temperatur, Strahlung, Wasser, Nährstoffe etc.) auf Organismen; Anpassung an bestimmte Umweltbedingungen
- Populationsdynamik: Ursachen, Beschreibung, Vorhersage und Regulation
- Interaktionen zwischen Arten (Konkurrenz, Koexistenz, Prädation, Parasitismus, Nahrungsnetze)
- Lebensgemeinschaften: Struktur, Stabilität, Sukzession
- Ökosysteme: Kompartimente, Stoff- und Energieflüsse
- Biodiversität: Variation, Ursachen, Gefährdung und Erhaltung
- Aktuelle Naturschutzprobleme und -massnahmen
- Evolutionäre Ökologie: Methodik, Spezialisierung, Koevolution

Lecture notes
Unterlagen, Vorlesungsskripten und relevante Literatur sind in Moodle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils spätestens am Freitagmorgen zur Verfügung.

Literature
Generelle Ökologie:

Aquatische Ökologie:
Lampert & Sommer 1999. Limnökologie. Thieme, 2. Aufl., ca. Fr. 55.;
Bohle 1995. Limnische Systeme. Springer, ca. Fr. 50.-

Naturschutzbiologie:
Lecture notes Wird von den jeweiligen Dozenten ausgegeben.

Literature Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

752-0100-00L Biochemistry

Abstract
Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo.
Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

Objective
Students are able to understand
- the structure and function of biological macromolecules
- the kinetic bases of enzyme reactions
- thermodynamic and mechanistic basics of relevant metabolic processes

Content
Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
Structure and function of proteins
Carbohydrates
Lipids and biological membranes
Enzymes and enzyme kinetics
Catalytic strategies
Metabolism: Basic concepts and design. Repetition of basic thermodynamics
Glycolysis, fermentation
The citric acid cycle
Oxidative phosphorylation
Fatty acid metabolism

Program

Lecture notes Horton et al. (Pearson) serves as lecture notes.

Prerequisites / notice
Basic knowledge in biology and chemistry is a prerequisite.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
</tbody>
</table>

Social Competencies

| Communication | not assessed |
| Cooperation and Teamwork | not assessed |
| Customer Orientation | not assessed |
| Leadership and Responsibility | not assessed |
| Self-presentation and Social Influence | not assessed |
| Sensitivity to Diversity | not assessed |

Personal Competencies

| Negotiation | not assessed |
| Adaptable and Flexibility | not assessed |
| Creative Thinking | assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | not assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and Self-management | not assessed |

5. Semester

Compulsory Courses 5. Semester

Urban Water Management II 102-0215-00L

Abstract

Objective
Consolidation of the basic procedures for design and operation of technical networks in water engineering.

Content
Demand Side Management versus Supply Side Management
Optimierung von Wasserverteilnetzen
Kalkausfällung, Korrosion von Leitungen
Hygiene in Verteilsystemen
Siedlungshydrologie: Niederschlag, Abflussbildung
Instationäre Strömungen in Kanalisations
Stofftransport in der Kanalisation
Einleitungsbetahren bei Regenwetter
Versickerung von Regenwasser
Generelle Entwässerungsplanung (GEP)

Lecture notes Written material will be available digital.

Prerequisites / notice
Prerequisite: Introduction to Urban Water Management
### 102-0455-01L Groundwater I

**Objective:** The course provides a quantitative introduction to groundwater flow and contaminant transport. In "Groundwater I" the competencies of process understanding are taught, applied and examined. Furthermore, system understanding and concept development are taught and applied, which are previous steps to groundwater modeling. To add measurement methods are taught and data analysis & interpretation is applied during the course.

**Content:** Understanding of the basic concepts on groundwater flow and contaminant transport processes. Formulation and solving of practical problems.

**Lecture notes** Script and collection of problems available

**Literature**
- W. Kinzelbach, R. Rausch, Grundwassermodellierung, Gebrüder Bornträger, Stuttgart, 1995

### 102-0635-01L Air Pollution Control

**Objective:** The students gain general knowledge of the technical processes resulting in air pollution and study the methods used for air pollution control. The students can identify major air pollution sources and understand the methods for measuring pollutants, collecting and analyzing data. The students can suggest and evaluate possible control methods and equipment, design control systems and estimate their efficiency and efforts.

**Content:**
- Part 1 Emission, Immission, Transmission
  - fluxes of pollutants and their environmental impact:
    - physical and chemical processes leading to emission of pollutants
    - mass and energy of processes
    - emission measurement techniques and concepts
    - quantification of emissions from individual and aggregated sources
    - extent and development of the emissions (Switzerland and global)
    - propagation and transport of pollutants (transmission)
    - meteorological parameters influencing air pollution dispersion
    - deterministic and stochastic models, describing air pollution dispersion
    - dispersion models (Gaussian model, box model, receptor model)
    - measurement concepts for ambient air (immission level)
    - extent and development of ambient air mixing ratios
    - goal and instrument of air pollution control

- Part 2 Air Pollution Control Technologies
  The reduction of the formation of pollutants is done by modifying the processes (pro-cessintegrated measures) and by different engineering operations for the cleaning of waste gas (downstream pollution control). It will be demonstrated, that the variety of these procedures can be traced back to the application of a few basic physical and chemical principles.

  Procedures for the removal of particles (inertial separator, filtration, electrostatic precipitators, scrubbers) with their different mechanisms (field forces, impaction and diffusion processes) and the modelling of these mechanisms.

  Procedures for the removal of gaseous pollutants and the description of the driving forces involved, as well as the equilibrium and the kinetics of the relevant processes (absorption, adsorption as well as thermal, catalytic and biological conversions).

**Lecture notes**
- Brigitte Buchmann, Air pollution control, Part I
- Jing Wang, Air pollution control, Part II
- Lecture slides and exercises

**Literature**
- List of literature included in script

**Prerequisites / notice**
- College lectures on basic physics, chemistry and mathematics.
- Language of instruction: In German or in English.
### Examination Block 4

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0031-02L</td>
<td>Business Administration</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>M. Passardi, P. Barmettler</td>
</tr>
</tbody>
</table>

#### Abstract
Introduction to business administration
Principles of accounting and financial management
Financial planning and capital budgeting of projects
Costing systems by corporations

#### Objective
Prepare and analyze the financial statements of organizations
Establish budget and determine profitability of investment
Understand the major costing systems
Perform some product calculations

#### Content
Overview in business administration

- Financial Accounting
  - Balance sheet, income statement
  - Accounts, double-entry bookkeeping
  - Year-end closing and financial statements

- Financial Management
  - Financial statement analysis
  - Financial planning
  - Investment decisions

- Management Accounting
  - Full costing and marginal costing
  - Product costing
  - Management decisions

#### Lecture notes
Nicht vorhanden.

#### Literature
Nicht vorhanden.
Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will
not assessed
not assessed
not assessed
Environmental Engineering Seminars
2V
Concepts and Theories
assessed
Techniques and Technologies
assessed
Analytical Competencies
assessed
Decision-making
assessed
Media and Digital Technologies
not assessed
Problem-solving
assessed
Project Management
not assessed
Communication
not assessed
Cooperation and Teamwork
not assessed
Customer Orientation
not assessed
Leadership and Responsibility
not assessed
Self-presentation and Social Influence
not assessed
Sensitivity to Diversity
not assessed
Negotiation
not assessed
Adaptability and Flexibility
not assessed
Creative Thinking
not assessed
Critical Thinking
assessed
Integrity and Work Ethics
not assessed
Self-awareness and Self-reflection
not assessed
Self-direction and Self-management
not assessed

851-0723-00L
Environmental Law I: Fundamentals and Concepts
Only for Environmental Engineering BSc
O
2 credits
2V
A. Gossweiler, C. Jäger, M. Pfüger

Abstract
This class introduces students to the fundamentals of legal systems, focusing on environmental law. It covers the fundamentals of constitutional and administrative law, as opposed to private and criminal law. The class will focus on concepts, terminology and procedures of Swiss environmental law and selected aspects of European environmental law, supplemented through case studies.

Objective
Students learn fundamental structures of the legal system, understand core concepts and selected problems of public law, focusing on Swiss and European environmental law. These insights can be applied in further law courses, in particular in the course “Environmental law: Areas and Case Studies.”

Content

Lecture notes
Christoph Jäger/Andreas Bühler, Schweizerisches Umweltrecht, Bern 2016

Literature
Weitere Literaturangaben folgen in der Vorlesung

101-0515-00L
Project Management
O
2 credits
2G
C. G. C. Marxt

Abstract
The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

Objective
The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project. Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Content
Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company wide success.

Lecture notes
No. The lecture slides and other additional material will be available for download from Moodle a week before each class.

Additional Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</table>

Abstract
The course is organized in the form of seminars held by the students. Topics selected from the core disciplines of the curriculum (water resources, urban water engineering, material fluxes, waste technology, air pollution, earth observation) are discussed in the class on the basis of scientific papers that are illustrated and critically reviewed by the students.

Objective
Learn about recent research results in environmental engineering and analyse practical applications in environmental engineering.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Media and Digital Technologies</td>
<td>Communication</td>
</tr>
<tr>
<td>Techniques and Theories</td>
<td>Media and Digital Technologies</td>
<td>Cooperation and Teamwork</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Media and Digital Technologies</td>
<td>Customer Orientation</td>
</tr>
<tr>
<td>Decision-making</td>
<td>Media and Digital Technologies</td>
<td>Self-presentation and Social Influence</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Media and Digital Technologies</td>
<td>Sensitivity to Diversity</td>
</tr>
<tr>
<td>Problem-solving</td>
<td>Media and Digital Technologies</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Project Management</td>
<td>Media and Digital Technologies</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Media and Digital Technologies</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Communication</td>
<td>Media and Digital Technologies</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Cooperation and Teamwork</td>
<td>Media and Digital Technologies</td>
<td>Self-awareness and Self-reflection</td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>Media and Digital Technologies</td>
<td>Self-direction and Self-management</td>
</tr>
</tbody>
</table>

Elective Blocks

Elective Block: Environmental Planning
The students will understand the basics of noise abatement: acoustics, impact of noise, measurement techniques and legislation. The students will be able to analyze different noise problems and they will be able to solve simple problems of noise abatement.

In the course "Noise Abatement", the competencies of process understanding, modeling, data analysis & interpretation and measurement methods are taught, applied and examined. System understanding is taught and examined.

Content
- Physikalische Grundlagen: Schallquellen, Wellen, Quellenarten.
- Lärmwirkungen: Gehör, Gesundheitliche Wirkungen von Lärm, Störung/Belästigung, Belastungsmaße.
- Schallausbreitung im Freien: Abstandsgesetze, Luftdämpfung, Bodenerfekt, Abschirmung, Reflexion, Streuung, Bebauung, Wettereinfüsse.
- Kurze Einführung in die Bauakustik und in die einfachsten Grundlagen der Raumakustik.

Lecture notes
- Skript "Lärmbekämpfung" als PDF ab Beginn der Vorlesung verfügbar.

Prerequisites / notice
- 1 - 2 Exkursionen

Elective Block: Soil Protection

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>701-0501-00L</td>
<td>Pedosphere</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Kretzschmar</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.</td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.</td>
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</tr>
<tr>
<td>Content</td>
<td>Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Polybook</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Prerequisites / notice</td>
<td>Prerequisites: Basic knowledge in chemistry, biology and geology.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories assessed, Techniques and Technologies assessed.</td>
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</tr>
<tr>
<td></td>
<td>Method-specific Competencies: Analytical Competencies assessed, Problem-solving assessed.</td>
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<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0533-00L</td>
<td>Soil and Water Chemistry</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. Kretzschmar, D. I. Christl, L. Winkel</td>
</tr>
<tr>
<td>Abstract</td>
<td>This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants. 2. Quantitative applications of chemical equilibria to processes in natural systems.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Content</td>
<td>Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.</td>
<td></td>
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</tr>
<tr>
<td>Lecture notes</td>
<td>Lecture slides on Moodle</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Prerequisites / notice</td>
<td>The lecture courses Pedosphere and Hydrosphere are highly recommended.</td>
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<tr>
<td>Fostered competencies</td>
<td>Subject-specific Competencies: Concepts and Theories assessed, Techniques and Technologies assessed.</td>
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<tr>
<td></td>
<td>Method-specific Competencies: Analytical Competencies assessed, Problem-solving assessed.</td>
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</tbody>
</table>

Elective Block: Civil Engineering

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>101-0339-00L</td>
<td>Environmental Geotechnics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Plötze</td>
</tr>
<tr>
<td>Abstract</td>
<td>Introduction of basic knowledge about problems with contaminated sites, investigation of this sites, risk management, remediation and reclamation techniques as well as monitoring systems. Introduction in landfill design and engineering with focus on barrier- and drainage systems and lining materials, evaluation of geotechnical problems, e.g. stability.</td>
<td></td>
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</tr>
</tbody>
</table>
Introduction of basic knowledge about problems with contaminated sites, investigation of these sites, risk management, remediation and reclamation techniques as well as monitoring systems.

In the course "Environmental Geotechnics", the competencies of process understanding, system understanding, concept development, and measurement methods are taught and examined.

Definition of contaminated sites, site investigation methods, historical research and technical investigation, risk assessment, contamination transport, remediation, clean-up and retaining techniques (e.g. bioremediation, incineration, retaining walls, pump-and-treat, permeable reactive barriers), monitoring, research projects and results

Waste, waste disposal, treatment and management, multi-barrier-systems, site investigation, lining systems and recovering systems of landfill (e.g. materials, drainage systems, geosynthetic), stability, research projects and results

**Prerequisites / notice**

**Fostered competencies**

**Subject-specific Competencies**
- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Theory of Structures (for Environmental Engineering)**

*Only for Environmental Engineering BSc.*

**Abstract**
Introduction to structural mechanics, statically determinate beams and frame structures, trusses. Stresses in statically determinate structures.

**Objective**
- Understanding the response of elastic beam and frame structures
- Ability to correctly apply the equilibrium conditions
- Understanding the basics of continuum mechanics
- Computation of stresses in elastic structures

In the course "Theory of Structures (for Environmental Engineering)", the competencies of process understanding, system understanding and modeling are taught and applied. The competence process understanding and system understanding are examined, too.

**Content**
- Equilibrium, reactions, static determinacy
- Internal forces (normal and shear forces, moments)
- Arches and cables
- Elastic trusses
- Influence lines
- Basics of continuum mechanics
- Stresses in elastic beams

**Lecture notes**
Bruno Sudret, "Einführung in die Baustatik", 2021
Available on Moodle with exercises.

**Literature**
B. Sudret, Baustatik - eine Einführung, 2022, Springer Vieweg.

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#### Elective Block: Energy

At least 10 KP must be achieved for the elective block: Energy.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>227-1635-00L</td>
<td>Electric Circuits</td>
<td>W</td>
<td>4 credits</td>
<td>3G</td>
<td>D. Shchetinin</td>
</tr>
</tbody>
</table>

**Abstract**
Students without a background in Electrical Engineering must take "Electric Circuits" before taking "Introduction to Electric Power Transmission: System & Technology"

**Objective**
At the end of this course, the student will be able to: understand variables in electric circuits, evaluate possible approaches and analyze simple electric circuits with RLC elements, apply circuit theorems to simple meshed circuits, analyze AC circuits in a steady state and understand the connection of the explained principles to the modeling of the 3-phase electric power systems.

**Content**
Course will introduce electric circuits variables, circuit elements (resistive, inductive, capacitive), resistive circuits and theorems (Kirchhoffs' laws, Norton and Thevenin equivalents), nodal and mesh analysis, superposition principle; it will continue by discussing the complete response circuits (RLC), sinusoidal analysis – ac steady state (complex power, reactive, active power) and conclude with the introduction to 3-phase analysis;

Mathematical foundations of the circuit analysis, such as matrix operations and complex numbers will be briefly reviewed.

This course is targeting students who have no prior background in electrical engineering.

**Lecture notes**
lecture and exercises slides will be distributed after each lecture via moodle platform; additional materials to be accessed online (wileyplus)
### Literature

Richard C. Dorf, James A. Svoboda

Introduction to Electric Circuits, 9th Edition

Online materials: https://www.wileyplus.com/

Lecture slides and exercises slides

### Prerequisites / notice

This course is intended for students outside of D-ITET. No prior course in electrical engineering is required.

### 151-1633-00L Energy Conversion

**W 4 credits 3G** I. Karlin, G. Sansavini

This course is intended for students outside of D-MAVT.

**Abstract**

Thermodynamics is key to understanding and use of energy conversion processes in Nature and technology. Main objective of this course is to give a compact introduction into basics of Thermodynamics: Thermodynamic states and thermodynamic processes: Work and Heat; First and Second Laws of Thermodynamics. Students shall learn how to use energy balance equation in the analysis of power cycles and shall be able to evaluate efficiency of internal combustion engines, gas turbines and steam power plants. The course shall extensively use thermodynamic charts to teach students about opportunities and restrictions to increase useful work output of energy conversion. Thermodynamic functions such as entropy, enthalpy and free enthalpy shall be used to understand chemical and phase equilibria. The course also gives introduction to refrigeration cycles, combustion and refrigeration. The course compactly covers the standard course of thermodynamics for engineers, with additional topics of a general physics interest (nonideal gas equation of state and Joule-Thomson effect) also included.

In the course "Energy Conversion", the competencies of process understanding and system understanding are applied and examined and the competencies process understanding and modeling are taught.

**Content**

1. Thermodynamic systems, states and state variables
2. Properties of substances: Water, air and ideal gas
3. Energy conservation in closed and open systems: work, internal energy, heat and enthalpy
4. Second law of thermodynamics and entropy
5. Energy analysis of steam power cycles
6. Energy analysis of gas power cycles
7. Refrigeration and heat pump cycles
8. Nonideal gas equation of state and Joule-Thomson effect
9. Maximal work and exergy
10. Mixtures
11. Chemical reactions and combustion systems; chemical and phase equilibrium

**Lecture notes**

Lecture slides and supplementary documentation will be available online.

**Literature**


**Prerequisites / notice**

This course is intended for students outside of D-MAVT.

Students are assumed to have an adequate background in calculus, physics, and engineering mechanics.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Techniques and Technologies</td>
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<td></td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Decision-making</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Problem-solving</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Project Management</td>
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</table>

<table>
<thead>
<tr>
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<th>Communication</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Leadership and Responsibility</td>
<td>assessed</td>
<td></td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Negotiation</td>
<td>not assessed</td>
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</table>

<table>
<thead>
<tr>
<th>Personal Competencies</th>
<th>Adaptability and Flexibility</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
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<tr>
<td>Critical Thinking</td>
<td>assessed</td>
<td></td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>assessed</td>
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</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
<td></td>
</tr>
</tbody>
</table>

**Electives**

The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

**Electives ETH Zurich**

Course Catalogue of ETH Zurich

**Science in Perspective**

**Science in Perspective**

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

**Language Courses**

see Science in Perspective: Language Courses ETH/UZH

**Bachelor’s Thesis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>102-0006-00L</td>
<td>Bachelor’s Thesis</td>
<td>O</td>
<td>10 credits</td>
<td>21D</td>
<td>Supervisors</td>
</tr>
</tbody>
</table>

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2155 of 2416
The Bachelor Programme concludes with the Bachelor Thesis. This project is supervised by a professor. Writing up the Bachelor Thesis encourages students to show independence and to produce structured work.

**Objective**
Encourages students to show independence, to produce scientifically structured work and to apply engineering working methods.

**Content**
The contents base upon the fundamentals of the Bachelor Programme. Students can choose from different subjects and tasks. The thesis consists of both a written report and an oral presentation.

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**Environmental Engineering Bachelor - Key for Type**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Key</th>
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</thead>
<tbody>
<tr>
<td>O</td>
<td>Compulsory</td>
<td>E-</td>
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<tr>
<td>W+</td>
<td>Eligible for credits and recommended</td>
<td>Z</td>
</tr>
<tr>
<td>W</td>
<td>Eligible for credits</td>
<td>E-</td>
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<td>W</td>
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<td>Z</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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**Key for Hours**

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<tbody>
<tr>
<td>V</td>
<td>lecture</td>
</tr>
<tr>
<td>G</td>
<td>lecture with exercise</td>
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<tr>
<td>U</td>
<td>exercise</td>
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<tr>
<td>S</td>
<td>seminar</td>
</tr>
<tr>
<td>K</td>
<td>colloquium</td>
</tr>
<tr>
<td>P</td>
<td>practical/laboratory course</td>
</tr>
<tr>
<td>A</td>
<td>independent project</td>
</tr>
<tr>
<td>D</td>
<td>diploma thesis</td>
</tr>
<tr>
<td>R</td>
<td>revision course / private study</td>
</tr>
</tbody>
</table>

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**ECTS**

European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Advanced Environmental, Social and Economic Assessments

The combined course unit is only for Master students in Environmental Engineering. All other students enrol for one or both of the single courses.

Abstract
This course deepens students' knowledge of environmental, economic, and social assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management

Content

Part I (Advanced Environmental Assessments)
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multioput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management
Students will get small excercises related to course issues.

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilias

Literature
Will be made available.

Prerequisites / notice
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5.2)).

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking

102-0307-01L Advanced Environmental, Social and Economic Assessments
- O
- 5 credits
- 4G
- A. E. Braunschweig, S. Pfister, A. Kim

102-0317-01L Advanced Environmental Assessment (Computer Lab)
- O
- 1 credit
- 1U
- S. Pfister

Abstract
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice.

Objective
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.
### Process Engineering in Urban Water Management

*No courses in autumn semester (HS), only in spring semester (FS).*

#### System Analysis in Urban Water Management

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0227-00L</td>
<td>Systems Analysis and Mathematical Modeling in Urban Water Management</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>E. Morgenroth, M. Maurer</td>
</tr>
</tbody>
</table>

**Abstract**


**Objective**

The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

**Content**

- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

**Lecture notes**

Copies of overheads will be made available.

**Literature**

There will be a required textbook that students need to purchase:


**Prerequisites / notice**

Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

---

### Fostered Competencies

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<th>assessed</th>
</tr>
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<tbody>
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<tr>
<td>Analytical Competencies</td>
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<tr>
<td>Critical Thinking</td>
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<tr>
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<tr>
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<tr>
<td>Cooperation and Teamwork</td>
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<td>Negotiation</td>
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<tr>
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### Process Engineering Ia

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<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>102-0217-00L</td>
<td>Process Engineering Ia</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>E. Morgenroth</td>
</tr>
</tbody>
</table>

**Abstract**

Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

**Objective**

Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

**Content**

- Stoichiometry
- Microbial transformation processes
- Introduction to design and modeling of activated sludge processes
- Anaerobic processes, industrial applications, sludge stabilization

**Literature**

There will be a textbook that students need to purchase (see [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html) for further information).

**Prerequisites / notice**

For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html)
In this course, the students learn modern urban drainage engineering approaches, critical thinking, decision making in a complex environment as well as dealing with insufficient data and ill-defined problems.

By the end of the course, you should be able to do the following:
- Apply different methods and methodologies to assess the impact of urban drainage on water pollution and flooding potential.
- Distinguish between hydrological and hydrodynamic models and their correct application.
- Identify the difference between emission and immersion oriented approaches for identifying drainage measures.
- Identify relevant measures, quantify their effects and assess their relative ranking/priority.
- Consider uncertainties and handle correctly incomplete data and information
- Make decisions and recommendations in a complex application case.
- Teamwork. State principles of effective team performance and the functions of different team roles; work effectively in problem-solving teams.
- Communication. Communicate and document your findings in concise group presentations and a written report.

The topics cover:
- Integrated urban water management
- Hydrological and hydrodynamic modelling
- Water quality based assessment
- Freshwater ecology
- Hydraulic capacity assessment
- Sewer network operation
- Decision analysis

In urban drainage, the complexity of the decision-making, the available methodologies and the data availability have increased strongly. In current environmental engineering practice, the focus shifted from tables and nomograms to sophisticated simulation tools.

Prerequisites: 102-0214-00 Siedlungswasserwirtschaft and 102-0215-00 Siedlungswasserwirtschaft II or comparable educational background.
Air Pollution Modeling and Chemistry

Abstract
Air pollutants cause negative effects on humans, wildlife and buildings. To control and reduce the impact of air pollutants, their transfer from sources to receptors needs to be known. This transfer includes transport within the atmospheric boundary layer, chemical transformation reactions and phase-transfer processes from gases to particles.

Objective
The students understand the fundamental principles of atmospheric transport, dispersion and chemistry of pollutants on the local to regional scale and their transfer gas to particle phases (secondary aerosols). This includes the knowledge of important atmospheric reactions, sources and sinks. The obtained understanding enables the students to apply computational tools to predict the transport and transformation of chemicals at the local to regional scale.

Content
- Structure of the Atmosphere
- Thermodynamics of the atmosphere
- Atmospheric stability
- Atmospheric boundary layer and turbulence
- Dispersion in the atmospheric boundary layer
- Numerical models of atmospheric dispersion
- Gas phase reaction kinetics
- Tropospheric chemistry and ozone formation
- Chemistry box models
- Volatile organic pollutants (VOCs) and semi-volatile organic pollutants (SVOCs)
- Aerosol modelling
- Air pollution source apportionment
- Inverse modelling of emissions

Lecture notes
Continued updates of:
- Slides and handouts
- Home assignments and sample solutions
- R package and code for some of the home assignments
- MATLAB codes
- Key journal articles as discussed during lecture

Literature

Process Engineering in Urban Water Management

No courses in autumn semester (HS), only in spring semester (FS).

System Analysis in Urban Water Management

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0227-00L</td>
<td>Systems Analysis and Mathematical Modeling in Urban Water Management</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>E. Morgenroth, M. Maurer</td>
</tr>
</tbody>
</table>

Number of participants limited to 50.

Abstract

Objective
The goal of this course is to provide the students with an understanding of urban water management, and to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.

Content
The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

Lecture notes
Copies of overheads will be made available.

Literature
There will be a required textbook that students need to purchase:

Prerequisites / notice
Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories (assessed)
- Techniques and Technologies (assessed)

Method-specific Competencies
- Analytical Competencies (assessed)
- Decision-making (assessed)
- Media and Digital Technologies (assessed)
- Problem-solving (assessed)

Social Competencies
- Communication (not assessed)
- Cooperation and Teamwork (not assessed)
- Customer Orientation (not assessed)
- Leadership and Responsibility (not assessed)
- Self-presentation and Social Influence (not assessed)
- Sensitivity to Diversity (not assessed)
- Negotiation (not assessed)

Personal Competencies
- Adaptability and Flexibility (not assessed)
- Critical Thinking (assessed)
- Integrity and Work Ethics (not assessed)
- Self-awareness and Self-reflection (not assessed)
- Self-direction and Self-management (not assessed)

Content
- Stoichiometry
- Microbial transformation processes
- Introduction to design and modeling of activated sludge processes
- Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice
For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

Waste Management

Remark: 102-0337-00 Landfilling, Contaminated Sites and Radioactive Waste Repositories only for those students also taking module "System Analysis in Urban Water Management" as replacement of 102-0217-00 Process Engineering Ia in module "Waste Management".

Number Title Type ECTS Hours Lecturers
102-0357-00L Waste Recycling Technologies O 3 credits 2G R. Bunge

Abstract
Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants processing contaminated soil, construction wastes, scrap metal, recovered paper and the like. While WRT is well established in Central Europe, it is only just now catching on in emerging markets as well.

Objective
At the core of this course is the separation of mixtures of solid bulk materials according to physical properties such as color, electrical conductivity, magnetism and so forth. After having taken this course, the students should have concept not only of the unit operations employed in WRT but also of how these unit operations are integrated into the flow sheets of production plants.
Introduction
Waste Recycling: Scope and objectives
Waste recycling technologies in Switzerland

Fundamentals
Properties of particles: Liberation conditions, Particle size and shape, Porosity of bulk materials
Fluid dynamics of particles: Stationary particle beds, Fluidized beds, Free settling particles
Flow sheet basics: Balancing mass flows
Standard processes: batch vs. continuous
Assessment of separation success: Separation function; grade vs. recovery

Separation Processes
Separation according to size and shape (Classification): Screening, Flow separation
Separation according to material properties (Concentration): Manual Sorting, Gravity concentration; Magnetic separation, Eddy current separation, Electrostatic separation, Sensor technology, Froth flotation

Lecture notes
The script consists of the slides shown during the lectures. Background material will be provided on the script-server.

Literature
A list of recommended books will be provided.

Prerequisites / notice
The topic will be discussed not from the perspective of theory, but rather in the context of practical application. However, solid fundamentals in physics (in particular in mechanics) are strongly recommended.

102-0337-00L  Landfilling, Contaminated Sites and Radioactive Waste Repositories

Only for Environmental Engineering MSc.

Abstract
Practices of landfilling and remediation of contaminated sites and disposal of radioactive waste are based on the same concepts that aim to protect the environment. The assessment of contaminants that may leach into the environment as a function of time and how to reduce the rate of their release is key to the design of chemical, technical and geological barriers.

Objective
Upon successful completion of this course students are able to:
- assess the risk posed to the environment of landfills, contaminated sites and radioactive waste repositories in terms of fate and transport of contaminants
- describe technologies available to minimize environmental contamination
- describe the principles in handling of contaminated sites and to propose and evaluate suitable remediation techniques
- explain the concepts that underlie radioactive waste disposal practices.

Content
This lecture course comprises of lectures with exercises and guided case studies.
- A short overview of the principles of environmental protection in waste management and how this is applied in legislation.
- A overview of the chemistry underlying the release and transport of contaminants from the landfill/contaminated material/radioactive waste repository focusing on processes that control redox state and pH buffer capacity; mobility of heavy metals and organic compounds
- Technical barrier design and function. Clay as a barrier.
- Contaminated site remediation: Site evaluation, remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

The competencies of process understanding, system understanding, concept development, and measurement methods are taught and examined.

Lecture notes
Short script plus copies of overheads

Literature
Literature will be made available.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
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<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Project Management</td>
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<td>Leadership and Responsibility</td>
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Prerequisites / notice
For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information.

102-0217-00L  Process Engineering Ia

Abstract
Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective
Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

Content
Stoichiometry
Microbial transformation processes
Introduction to design and modeling of activated sludge processes
Anaerobic processes, industrial applications, sludge stabilization

Literature
There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice
For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html
Major Resource Management

Ecological System Design

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
102-0307-01L | Advanced Environmental, Social and Economic Assessments | O | 5 credits | 4G | A. E. Braunschweig, S. Pfister, A. Kim

Abstract
This course deepens students' knowledge of environmental, economic, and social assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management

Content
Part I (Advanced Environmental Assessments)
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including 'organisational LCA' (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecopoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small exercises related to course issues.

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilias

Literature
Will be made available.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2163 of 2416
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5, 2)).

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Problem-solving: assessed

- **Personal Competencies**
  - Creative Thinking: assessed
  - Critical Thinking: assessed

---

### Groundwater

**Module is offered in Spring Semester.**

### Waste Management

**Remark:** 102-0337-00 Landfilling, Contaminated Sites and Radioactive Waste Repositories only for those students also taking module "System Analysis in Urban Water Management" as replacement of 102-0217-00 Process Engineering la in module "Waste Management".

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<tr>
<td>102-0357-00L</td>
<td>Waste Recycling Technologies</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>R. Bunge</td>
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<td><strong>Abstract</strong></td>
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<tr>
<td><strong>Content</strong></td>
<td>Introduction: Waste Recycling; Scope and objectives</td>
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<td>102-0337-00L</td>
<td>Landfilling, Contaminated Sites and Radioactive Waste Repositories</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Plötte, W. Hummel</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Practices of landfilling and remediation of contaminated sites and disposal of radioactive waste are based on the same concepts that aim to protect the environment. The assessment of contaminants that may leach into the environment as a function of time and how to reduce the rate of their release is key to the design of chemical, technical and geological barriers.</td>
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<tr>
<td><strong>Objective</strong></td>
<td>Upon successful completion of this course students are able to:</td>
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<tr>
<td>Lecture notes</td>
<td>Short script plus copies of overheads</td>
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<tr>
<td>Literature</td>
<td>Literature will be made available.</td>
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</tbody>
</table>
Process Engineering Ia  

**Abstract**

Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

**Objective**

Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

**Content**

- Stoichiometry
- Analytical Competencies: Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Personal Competencies: Adaptability and Flexibility, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

**Literature**

There will be a textbook that students need to purchase (see [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html) for further information).

**Prerequisites / notice**

For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html)

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**Watershed Modelling**

**Abstract**

Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

**Objective**

The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

**Content**

The first part (A) of the course is on watershed properties obtained from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.
In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and methods to foster ecological processes in landscapes.

**Major Water Resources Management**

**Flow and Transport**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
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</tr>
</thead>
<tbody>
<tr>
<td>101-0267-01L</td>
<td>Numerical Hydraulics</td>
<td>O</td>
<td>3</td>
<td>2G</td>
<td>M. Holzner</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way.</td>
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<td></td>
<td>Content</td>
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<tr>
<td></td>
<td>The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.</td>
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</table>

All methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

**Literature**

- Lecture notes: Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.
- Literature: Collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

**Groundwater**

Module is offered in Spring Semester.

**Landscape**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>103-0347-00L</td>
<td>Landscape Planning and Environmental Systems</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>A. Grêt-Regamey</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>The aims of this course are:</td>
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<tr>
<td></td>
<td>1) To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).</td>
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<td>2) To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.</td>
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<td>3) To show the importance of ecosystem services.</td>
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<td></td>
<td>4) To teach basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).</td>
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<td></td>
<td>5) To identify and measure the characteristics of landscape.</td>
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<td></td>
<td>6) Learn how to use spatial data in landscape planning.</td>
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</tbody>
</table>
In this course, the following topics are discussed:

- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.

102-0287-00L River Basin Erosion

Abstract
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Objective
The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g., thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

Content
The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes
There is no script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

Prerequisites
Basic Hydrology and Watershed Modelling (or contact instructor).

Water Resources Management

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>102-0468-10L</td>
<td>Watershed Modelling</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>P. Molnar</td>
</tr>
</tbody>
</table>

Abstract
Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective
The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.
The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphology, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Lecture notes
There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.

Literature
Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<tr>
<td></td>
<td>Problem-solving</td>
</tr>
</tbody>
</table>

Analytical and Theoretical

Social Competencies
Communication
Cooperation and Teamwork

Personal Competencies
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

Concepts and Theories

In this course Numerical Hydraulics the basics of numerical modelling of flows are presented. The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use commercial software in a responsible and critical way. The basic equations are derived from first principles. Possible simplifications relevant for practical problems are shown and their applicability is discussed. Using the example of non-steady state pipe flow numerical methods such as the method of characteristics and finite difference methods are introduced. The finite volume method as well as the method of characteristics are used for the solution of the shallow water equations. Special aspects such as wave propagation and turbulence modelling are also treated.

Methods discussed are applied practically in exercises. This is done using programs in MATLAB which partially are programmed by the students themselves. Further, some generally available softwares such as BASEMENT for non-steady shallow water flows are used.

Lecture notes
Lecture notes, powerpoints shown in the lecture and programs used can be downloaded. They are also available in German.

Literature
Given in lecture

Ecohydrologists and Habitat Modelling
At a time in which humans have significantly affected the natural environment and yet society increasingly values the many services of natural ecosystems, accounting for ecological processes in engineering design is a major contemporary challenge for environmental and civil engineers.

This is the fundamental topic in ecohydraulics, the discipline that focuses on the consequences of fluid flow and related physical processes on the organisms that inhabit aquatic environments. While still a young science, ecohydraulics already endows the engineer with an overall understanding and quantitative tools to predict how physical processes shape habitat quality and quantity, enabling the analysis of different management options for natural and man-made water bodies in terms of their ecosystem consequences.

This class will take a broad view of ecohydraulics and introduce students to key concepts in aquatic habitat modeling. Recognizing that an ecosystem is composed of diverse organisms with different seasonal habitat requirements across a range of scales, the class will focus on multiple representative groups of organisms, including fish, macroinvertebrates, plankton, and vegetation. The lectures will build on the students' knowledge of hydraulics, to give them both an appreciation for the dependence of organisms on their physical environment and a set of quantitative modeling approaches that they can take with them into engineering practice, in fields ranging from hydropower development and upgrade, to reservoir operation, river restoration, flood protection, water management and beyond. At the broadest scale, this class will contribute to the students' appreciation of the tight link between the natural and the built or impacted environment, and of the imperatives of considering both in the design process.

Hydraulic Engineering

Hydraulic structures II
Information: Enrolment of Hydraulic Engineering II is not recommended without having attended Hydraulic Engineering (101-0206-00L) previously since Hydraulic Engineering II is strongly based on Hydraulic Engineering (101-0206-00L).

Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design with regard to economy and safety are provided.

Knowledge of hydraulic structures and their function within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.

K. Sperger, I. Albayrak, F. Evers, B. Hohermuth

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 2168 of 2416
Content

Weirs: Weir stability, gates, inflatable dams, appurtenant structures, fish up- and downstream passages.
Conduits: Design of headraces, pressure shafts, and penstocks, constructive details and construction.
Power plants: Power house and turbine types, design, structure, construction.
Dams: Types, appurtenant structures (temporary diversions, spillways, bottom and low-level outlets), dam type selection criteria, layout and design of gravity dams, buttress dams, arch dams, rockfill dams with central core or concrete face, measures in the foundation, mass concrete, RCC dams, reservoir siltation and sediment management, dam surveillance.
Artificial reservoirs: Purpose, layout, sealing, appurtenant structures, environmental aspects.

Lecture notes

manuscript and further documentation

Literature

is specified in the lecture and in the manuscript

Prerequisites / notice

Information: Because Hydraulic Structures II is strongly based on Hydraulic Engineering (101-0206-00L) it is strongly recommended to have taken this course (101-0206-00L) or a similar one previously.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Personal Competencies
Self-direction and Self-management not assessed

River Systems

Remark: partly in German.

Note: Students taking both of the modules LAND and RIVER must take the course 101-1250-00 Wildbach- und Hangverbau as replacement for for Fluvial Systems that is listed in both modules.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>101-0258-00L</td>
<td>River Engineering</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>V. Weitbrecht, I. Schalko, K. Sperger</td>
</tr>
</tbody>
</table>

Abstract

The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

Objective

At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

Content

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

Lecture notes

Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

Literature

1. «Flussbau» lecture notes of fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance)
2. Erosion and Sedimentation; Pierre Y. Julien
3. River Mechanics; Pierre Y. Julien

Prerequisites / notice

Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making not assessed
Problem-solving assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed

Personal Competencies
Creative Thinking not assessed
Critical Thinking assessed
Self-direction and Self-management not assessed

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>101-0287-00L</td>
<td>River Basin Erosion</td>
<td>O</td>
<td>3 credits</td>
<td>2G</td>
<td>P. Molnar</td>
</tr>
</tbody>
</table>

Abstract

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Objective

The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will lean about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.
Content

The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes

There is no script.

Literature

The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice

Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

Water Resources Management

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>102-0468-10L</td>
<td>Watershed Modelling</td>
<td>O</td>
<td>6</td>
<td>4G</td>
<td>P. Molnar</td>
</tr>
<tr>
<td>Abstract</td>
<td>Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).</td>
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<tr>
<td>Objective</td>
<td>The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a term-end oral examination (30 mins) on watershed modelling concepts.</td>
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<tr>
<td>Content</td>
<td>The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about component models for soil water fluxes and transformation reactions and phase-transfer processes from gases to particles.</td>
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<tr>
<td>Lecture notes</td>
<td>There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.</td>
<td></td>
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</tr>
<tr>
<td>Literature</td>
<td>Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.</td>
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<tr>
<td>Prerequisites / notice</td>
<td>Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).</td>
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Project Work (for all Majors)

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>102-0999-00L</td>
<td>Project Work</td>
<td>O</td>
<td>12</td>
<td>26A</td>
<td>Supervisors</td>
</tr>
<tr>
<td>Abstract</td>
<td>Working during one semester on a task on a topic in the chosen major</td>
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<tr>
<td>Objective</td>
<td>Promote independent, structured and scientific work; learn to apply engineering methods; deepen the knowledge in the field of the treated task.</td>
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<tr>
<td>Content</td>
<td>The project work is supervised by a professor. Students can choose from different subjects and tasks.</td>
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</table>

Elective Modules

For all majors.

EM: Air Quality Control


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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>102-0377-00L</td>
<td>Air Pollution Modeling and Chemistry</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. Henne, S. Reimann Bhend, X. Zhang</td>
</tr>
<tr>
<td>Abstract</td>
<td>Air pollutants cause negative effects on humans, wildlife and buildings. To control and reduce the impact of air pollutants, their transfer from sources to receptors needs to be known. This transfer includes transport within the atmospheric boundary layer, chemical transformations, reactions and phase-transfer processes from gases to particles.</td>
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<tr>
<td>Objective</td>
<td>The students understand the fundamental principles of atmospheric transport, dispersion and chemistry of pollutants on the local to regional scale and their transfer gas to particle phases (secondary aerosols). This includes the knowledge of important atmospheric reactions, sources and sinks. The obtained understanding enables the students to apply computational tools to predict the transport and transformation of chemicals at the local to regional scale.</td>
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</tbody>
</table>
Content
- Structure of the Atmosphere
- Thermodynamics of the atmosphere
- Atmospheric stability
- Atmospheric boundary layer and turbulence
- Dispersion in the atmospheric boundary layer
- Numerical models of atmospheric dispersion
- Gas phase reaction kinetics
- Tropospheric chemistry and ozone formation
- Chemistry box models
- Volatile organic pollutants (VOCs) and semi-volatile organic pollutants (SVOCs)
- Aerosol modelling
- Air pollution source apportionment
- Inverse modelling of emissions

Lecture notes
Continued updates of:
- Slides and handouts
- Home assignments and sample solutions
- R package and code for some of the home assignments
- MATLAB codes
- Key journal articles as discussed during lecture

Literature
Atmospheric chemistry

Environmental organic chemistry and mass transfer
Mackay D., Multimedia environmental models : the fugacity approach; Boca Raton, Fla. : Lewis Publishers; 2001; 2nd ed

Atmospheric dynamics and boundary layer

Atmospheric modelling

Introduction to R

Prerequisites / notice
strongly recommended: 102-0635-01L Luftreinhaltung (Air Pollution Control) or similar

EM: Ecological Systems Design
Elective Module for Majors "Environmental Technologies", "River and Hydraulic Engineering" and "Water Resources Management".

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>102-0307-01L</td>
<td>Advanced Environmental, Social and Economic Assessments</td>
<td>W</td>
<td>5 credits</td>
<td>4G</td>
<td>A. E. Braunschweig, S. Pfister, A. Kim</td>
</tr>
</tbody>
</table>

Abstract
This course deepens students' knowledge of environmental, economic, and social assessment methodologies and their various applications.

Objective
This course has the aim of deepening students' knowledge of the environmental, economic and social assessment methodologies and their various applications.

In particular, students completing the course should have the
- ability to judge the scientific quality and reliability of environmental assessment studies, the appropriateness of inventory data and modelling, and the adequacy of life cycle impact assessment models and factors
- knowledge about the current state of the scientific discussion and new research developments
- ability to properly plan, conduct and interpret environmental assessment studies

In the course element "Implementation of Environmental and other Sustainability Goals", students will learn to
- describe key sustainability problems of the current economic system and measuring units.
- describe the management system of an organisation and how to develop a sustainability orientation
- discuss approaches to measure environmental performance of an organisation, including 'organisational LCA' (Ecobalance)
- explain the pros and cons of single score environmental assessment methods
- demonstrate life cycle costing
- interpret stakeholder relations of an organisation
- (if time allows) describe sustainable supply chain management and stakeholder management
In the course Numerical Hydraulics the basics of numerical modelling of flows are presented.

The goal of the course is to develop the understanding of the students for numerical simulation of flows to an extent that they can later use Numerical Hydraulics.

Part II (Implementation of Environmental and other Sustainability Goals):
- Sustainability problems of the current economic system and its measuring units;
- The structure of a management system, and elements to integrate environmental management (ISO 14001) and social management (SA8000 as well as ISO 26000), especially into strategy development, planning, controlling and communication;
- Sustainability Opportunities and Innovation
- The concept of 'Continuous Improvement'
- Life Cycle Costing, Life Cycle Management
- environmental performance measurement of an organisation, including 'organisation LCA' (Ecobalance), based on practical examples of companies and new concepts
- single score env. assessment methods (Swiss ecospoints)
- stakeholder management and sustainability oriented communication
- an intro into sustainability issues of supply chain management

Students will get small excercises related to course issues.

Literature
Will be made available.

Prerequisites / notice
This course should only be elected by students of environmental engineering with a with a Module in Ecological Systems Design. All other students should take the individual courses in Advanced Environmental Assessment and/or Implementation of Environmental and other Sustainability goals (with or without exercise and lab).

Basic knowledge of environmental assessment tools is a prerequisite for this class. Students who have not yet had classwork in this topic are required to read an appropriate textbook before or at the beginning of this course (e.g. Jolliet, O et al. (2016). Environmental Life Cycle Assessment. CRC Press, Boca Raton - London - New York. ISBN 978-1-4398-8766-0 (Chapters 2-5,2)).

Content
- Inventory database developments, transparency, data quality, data completeness, and data exchange formats, uncertainties
- Software tools (MFA, LCA)
- Allocation (multioutput processes and recycling)
- Hybrid LCA methods.
- Consequential and marginal analysis
- Impact assessment of waterborne chemical emissions, sum parameters, mixture toxicity
- Spatial differentiation in Life Cycle Assessment
- Workplace and indoor exposure in Risk and Life Cycle Assessment
- Subjectivity in environmental assessments
- Multicriteria Decision Analysis
- Case Studies

Lecture notes
Part I: Slides and background reading material will be available on lecture homepage
Part II: Documents will be available on Ilias

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking

102-0317-03L Advanced Environmental Assessment (Computer Lab) W 1 credit 1U S. Pfister

I

Abstract
Different tools and software used for environmental assessments, such as LCA are introduced. The students will have hands-on exercises in the computer rooms and will gain basic knowledge on how to apply the software and other resources in practice

Objective
Become acquainted with various software programs for environmental assessment including Life Cycle Assessment, Environmental Risk Assessment, Probabilistic Modeling, Material Flow Analysis.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Problem-solving

Personal Competencies
- Creative Thinking
- Critical Thinking

102-0259-00L Ecohydraulics and Habitat Modelling W 3 credits 2G R. Stocker, K.-D. Jorde,
L. G. Martins da Silva, A. Siviglia

Abstract
At a time in which humans have significantly affected the natural environment and yet society increasingly values the many services of natural ecosystems, accounting for ecological processes in engineering design is a major contemporary challenge for environmental and civil engineers.

Objective
This is the fundamental topic in ecohydraulics, the discipline that focuses on the consequences of fluid flow and related physical processes on the organisms that inhabit aquatic environments. While still a young science, ecohydraulics already endows the engineer with an overall understanding and quantitative tools to predict how physical processes shape habitat quality and quantity, enabling the analysis of different management options for natural and man-made water bodies in terms of their ecosystem consequences.
This class will take a broad view of ecohydraulics and introduce students to key concepts in aquatic habitat modeling. Recognizing that an ecosystem is composed of diverse organisms with different seasonal habitat requirements across a range of scales, the class will focus on multiple representative groups of organisms, including fish, macroinvertebrates, plankton, and vegetation. The lectures will build on the students’ knowledge of hydraulics, to give them both an appreciation for the dependence of organisms on their physical environment and a set of quantitative modeling approaches that they can take with them into engineering practice, in fields ranging from hydropower development and upgrade, to reservoir operation, river restoration, flood protection, water management and beyond. At the broadest scale, this class will contribute to the students’ appreciation of the tight link between the natural and the built or impacted environment, and of the imperatives of considering both in the design process.

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**>> EM: Groundwater**

**Elective Module for Majors “Environmental Technologies”, “River and Hydraulic Engineering” and “Urban Water Management”.**

Module is offered in FS.

**>> EM: Hydraulic Engineering**


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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>101-0247-01L</td>
<td>Hydraulic structures II</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>K. Sperger, I. Albayrak, F. Evers, B. Hohermuth</td>
</tr>
</tbody>
</table>

**Abstract**

Hydraulic structures and their functions within hydraulic systems are treated in this lecture. The basic concepts of their layout and design with regard to economy and safety are provided.

**Objective**

Knowledge of hydraulic structures and their functions within hydraulic systems. Skills for the layout and design of hydraulic structures with regard to economy and safety.

**Content**

- Weirs: Weir stability, gates, inflatable dams, appurtenant structures, fish upstream and downstream passages.
- Conduits: Design of headfaces, pressure shafts, and penstocks, constructive details and construction.
- Power plants: Power house and turbine types, design, structure, construction.
- Dams: Types, appurtenant structures (temporary diversions, spillways, bottom and low-level outlets), dam type selection criteria, layout and design of gravity dams, buttress dams, arch dams, rockfill dams with central core or concrete face, measures in the foundation, mass concrete, RCC dams, reservoir siltation and sediment management, dam surveillance.

**Lecture notes**

Manuscript and further documentation is specified in the lecture and in the manuscript.

**Prerequisites / notice**

Information: Because Hydraulic Structures II is strongly based on Hydraulic Engineering (101-0206-00L), it is strongly recommended to have taken this course (101-0206-00L) or a similar one previously.

**Fostered competencies**

- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies
- Method-specific Competencies: Analytical Competencies, Decision-making, Problem-solving
- Personal Competencies: Self-direction and Self-management

**>> EM: Landscape**


<table>
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<tr>
<th>Number</th>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>103-0347-00L</td>
<td>Landscape Planning and Environmental Systems</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>A. Grêt-Regamey</td>
</tr>
</tbody>
</table>

**Abstract**

In the course, students learn about methods for the identification and measurement of landscape characteristics, as well as measures and policies for landscape planning. Landscape planning is put into the context of environmental systems (soil, water, air, climate, flora and fauna) and discussed with regard to socio-political questions of the future.

**Objective**

The aims of this course are:

1. To illustrate the concept of landscape planning, the economic relevance of landscape and nature in the context of the environmental systems (soil, water, air, climate, flora and fauna).
2. To show landscape planning as an integral information system for the coordination of different instruments by illustrating the aims, methods, instruments and their functions in landscape planning.
3. To show the importance of ecosystem services.
4. To learn basics about nature and landscape: Analysis and assessment of the complex interactions between landscape elements, effects of current and future land use (ecosystem goods and services, landscape functions).
5. To identify and measure the characteristics of landscape.
6. To learn how to use spatial data in landscape planning.

**Content**

In this course, the following topics are discussed:

- Definition of the concept of landscape
- Relevance of landscape planning
- Landscape metrics
- Landscape change
- Methods, instruments and aims of landscape planning (policy)
- Socio-political questions of the future
- Environmental systems, ecological connectivity
- Ecosystem services
- Urban landscape services
- Practice of landscape planning
- Use of GIS in landscape planning

**Lecture notes**

No script. The documentation, consisting of presentation slides are partly handed out and are provided for download on Moodle.

**Prerequisites / notice**

The contents of the course will be illustrated in the associated course 103-0347-01 U (Landscape Planning and Environmental Systems (GIS Exercises)) or in Project LAND within the Experimental and Computer Lab (for Environmental Engineers). A combination of courses is recommended.
River Basin Erosion

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

### Content

- Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented.
- Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales.
- The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples.
- Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

### Literature

The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

### Prerequisites / notice

Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

#### EM: Process Engineering in Urban Water Management

*Elective Module for Majors "Resource Management", "River and Hydraulic Engineering" and "Water Resources Management".*

No courses in autumn semester (HS), only in spring semester (FS).

#### EM: Remote Sensing and Earth Observation


*Remark: Students also taking module "Remote Sensing and Earth Observation" as replacement of 102-0617-01L Methodologies for Image Processing of Remote Sensing Data in module "Landscape" have to chose one out following list: 701-1674-00L Spatial Analysis, Modelling and Optimisation (FS) or 701-1644-00L Mountain Forest Hydrology (HS).*

### EM: Remote Sensing and Earth Observation


*Remark: Students also taking module "Remote Sensing and Earth Observation" as replacement of 102-0617-01L Methodologies for Image Processing of Remote Sensing Data in module "Landscape" have to chose one out following list: 701-1674-00L Spatial Analysis, Modelling and Optimisation (FS) or 701-1644-00L Mountain Forest Hydrology (HS).*

### Number Title

| 102-0617-00L Basics and Principles of Radar Remote Sensing for Environmental Applications | W | 3 | 2G | I. Hajnsek |

### Abstract

The course will provide the basics and principles of Radar Remote Sensing (specifically Synthetic Aperture Radar (SAR)) and its imaging techniques for the use of environmental parameter estimation.

### Objective

The course should provide an understanding of SAR techniques and the use of the imaging tools for bio/geophysical parameter estimation. At the end of the course the student has the understanding of:

1. SAR basics and principles,
2. SAR polarimetry,
3. SAR interferometry and
4. environmental parameter estimation from multi-parametric SAR data

### Content

The course is giving an introduction into SAR techniques, the interpretation of SAR imaging responses and the use of SAR for different environmental applications. The outline of the course is the following:

1. Introduction into SAR basics and principles
2. Introduction into electromagnetic wave theory
3. Introduction into scattering theory and decomposition techniques
4. Introduction into SAR interferometry
5. Introduction into polarimetric SAR interferometry
6. Introduction into bio/geophysical parameter estimation (classification/segmentation, soil moisture estimation, earth quake and volcano monitoring, forest height inversion, wood biomass estimation etc.)

### Lecture notes

Handouts for each topic will be provided.
First readings for the course:
O. Frey

Handouts and powerpoint presentations shown in the lecture can be downloaded via Moodle.

Lecture notes/handouts for each topic will be provided online.

Additional reading material:

https://doi.org/10.1007/0-306-47633-9

It is highly recommended that the student has previously taken the following courses:
102-0617-00L: Basics and Principles of Radar Remote Sensing and
102-0617-01L: Methodologies for Image Processing of Remote Sensing Data

**EM: River Systems**


Remark: partly in German.

**Note:** Students taking both of the modules LAND and RIVER must take the course 101-1250-00 Wildbach- und Hangverbau as replacement for for Fluval Systems that is listed in both modules.

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>101-0258-00L</td>
<td>River Engineering</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>V. Weitbrecht, I. Schalko, K. Sperger</td>
</tr>
</tbody>
</table>

**Abstract**

The lecture addresses the fundamentals of river engineering to quantitatively describe the flow of water, transport of sediment and wood, and morphological changes such as erosion and deposition processes associated with river structures. In addition, design guidelines for river engineering structures are introduced.

**Objective**

At the end of the course, the students will be able to:
- recall and describe the fundamentals of transport processes in rivers,
- apply different calculation approaches and methods to tackle river engineering problems and tasks such as the discharge capacity of a river, scour estimation, or sediment budget of a river,
- design and dimension river engineering works needed to influence the processes in watercourses, and
- determine the interaction between flow (discharge), sediment transport, wood transport and the resulting channel evolution.

**Content**

The first part of the lecture introduces the fundamentals of river engineering, such as methods to determine and calculate the river discharge, or sampling methods to characterize the bed material. In addition, the transport processes of sediment (bedload and suspended load) and wood in rivers will be examined, including the principles of incipient motion, and initiation of erosion or deposition processes.

In the second part of the lecture, the methods will be explained to quantify the bed load budget and the morphological changes (erosion, deposition) in river systems. Specifically, natural channel formation processes, different bed forms and plan forms of rivers (straight, meandering, braided) are examined.

The last part of the lecture focuses on the design of river engineering structures, including examples from an ongoing flood and river revitalization project at the Alpine Rhine in Austria and Switzerland.

**Literature**

1. «Flussbau» lecture notes of fall semester 2021 by Dr. Gian Reto Bezzola (available only in German at VAW teaching assistance)
2. Erosion and Sedimentation; Pierre Y. Julien
3. River Mechanics; Pierre Y. Julien

**Prerequisites / notice**

Recommended lectures:
Hydrology (102-0293-AAL), Hydraulics I (101-0203-01L), and Hydraulic Engineering (101-0206-00L).

Short practical exercises (voluntary) will be offered throughout the semester to improve the application of the learned subjects.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Problem-solving: assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed

Personal Competencies
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Self-direction and Self-management: not assessed

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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>102-0287-00L</td>
<td>River Basin Erosion</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>P. Molnar</td>
</tr>
</tbody>
</table>

Abstract
The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

Objective
(1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, such as thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about fundamental landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment through the fluvial system.

Content
The course consists of four sections:
1. Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modeling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet-rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

Lecture notes
There is no script.

Literature
The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

Prerequisites / notice
Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

EM: Soil

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<th>Lecturers</th>
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<tr>
<td>701-0535-00L</td>
<td>Environmental Soil Physics/Vadose Zone Hydrology</td>
<td>W</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Carminati, P. U. Lehmann Grunder</td>
</tr>
</tbody>
</table>

Abstract
The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

Objective
Students are able to:
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils
Soil-Plant Water Relations

Water limitation is a primary constraint on plant growth and terrestrial fluxes worldwide. In this course, the principles of water flow in soil and the plant water relations will be studied, starting from the basic concepts and extending to the application of computational models in soil-plant-atmospheric systems. The students are expected to develop their own mathematical models, to plan and to perform numerical simulations of water flow in soils and plants, and to evaluate their results in relation to real-world conditions.

Prerequisites:
- Prior knowledge of soil physics and soil chemistry
- Basic understanding of mathematical modeling

Literature:
- Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel
- Lecture notes; selection of articles

Content
- Week 1 (September 21): Introduction, content, structure of the course, objectives, bibliography, grading and evaluation; soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density.
- Week 2 (September 28): Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation; surface tension; Young-Laplace equation; capillary rise; contact angle.
- Week 3 (October 05): Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (including report)
- Week 4 (October 12): Soil water content; soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point.
- Week 5 (October 19): Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; Demo lab (including report)
- Week 6 (October 26): Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman); effective conductivity; unsaturated hydraulic conductivity; Buckingham law.
- Week 7 (November 02): Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow
- Week 8 (November 09): Numerical solution of Richards equation -- Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)
- Week 9 (November 16): Solute and gas transport in soils - Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.
- Week 10 (November 23): Conductivity and resistance of soils -- differences and similarities of hydraulic, electrical, thermal conductivities; Buckingham-Darcy, Fourier, and Archie's law; pore scale characteristics and effective conductivities; soil thermal properties; steady state and non-steady heat flow
- Week 11 (November 30): Energy balance and land atmosphere interactions - Radiation and energy balance; evapotranspiration, potential and actual evaporation, definitions and estimation; evaporation stages and characteristic length
- Week 12 (December 07): Root water uptake and transpiration -- Mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance
- Week 13 (December 14): Summary, questions, old exam
- Week 14 (December 21): Written Semester-end exam

Literature
- Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel
- Lecture notes; selection of articles

701-1343-00L Soil-Plant Water Relations

| Number of participants limited to 40. Priority is given to the target groups: Master Environmental Sciences, Master Agricultural Sciences and Master Environmental Engineering until 29.03.2022. Waiting list will be deleted 02.10.2022. |

Abstract
Water limitation is a primary constraint on plant growth and terrestrial fluxes worldwide. In this course, the principles of water flow in soil and plants are discussed, with particular attention on the effect of drought on root water uptake, transpiration and plant growth. Strategies of plants to tolerate drought are discussed.

Objective
The students are able to: explain and compare systematically the drivers of water stress to plants; to solve the equations of water flow in soil and plants and to calculate plant water status for varying pedoclimatic conditions and plant traits; to critically review and present one research question in soil-plant water relations; to openly debate on the current trends in soil and plant water research.

Content
23.09: Introduction.
30.09: Soil water relations; Principles of soil water retention and soil water flow; Soil hydraulic properties.
07.10: Root water uptake; soil hydraulic constraints on transpiration
14.10: Rhizosphere processes and properties; root-soil contact; root hairs; mycorrhiza; rhizodeposition.
21.10: Water flow in roots and xylem; root anatomy and architecture; caviation.
28.10: Transpiration; Vapor Pressure Deficit; Photosynthesis; Stomatal regulation.
04.11: Soil-plant-atmospheric continuum; Below- and above-ground feedbacks; Soil and atmospheric drivers of transpiration losses.
11.11: Modelling Soil-Plant Water Relations (Concept)
18.11: Modelling Soil-Plant Water Relations (Implementation)
25.11: Plant response to drought and consequences for agriculture and forests. Open questions and introduction to seminar topics.
02.12: Independent work (no class)
09.12: Seminar (presentation of papers)
16.12: Seminar (presentation of papers)
23.12: Seminar (presentation of papers)

Literature
Lecture notes; selection of articles

Prerequisites / notice

EM: System Analysis in Urban Water Management

Elective Module for Majors "Resource Management", "River and Hydraulic Engineering" and "Water Resources Management".

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<th>Title</th>
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<tbody>
<tr>
<td>102-0227-00L</td>
<td>Systems Analysis and Mathematical Modeling in Urban Water Management</td>
<td>W</td>
<td>6 credits</td>
<td>4G</td>
<td>E. Morgenroth, M. Maurer</td>
</tr>
</tbody>
</table>

Abstract

Objective
The goal of this course is to provide the students with an understanding and the tools to develop their own mathematical models, to plan experiments, to evaluate error propagation and to test simple process control strategies in the field of process engineering in urban water management.
Content

The course will provide a broad introduction into the fundamentals of modeling water treatment systems. The topics are:
- Introduction into modeling and simulation
- The material balance equations, transport processes, transformation processes (kinetics, stoichiometry, conservation)
- Ideal reactors
- Hydraulic residence time distribution and modeling of real reactors
- Dynamic behavior of reactor systems
- Systems analytical tools: Sensitivity, parameter identification, error propagation, Monte Carlo simulation
- Introduction to process control (PID controller, fuzzy control)

Lecture notes

Copies of overheads will be made available.

Literature

There will be a required textbook that students need to purchase:

Prerequisites / notice

Students should have a general understanding of urban water management as many examples are taken from processes relevant to related systems. This course is offered in parallel with the course Process Engineering Ia. It is beneficial but not necessary to follow both courses simultaneously.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

102-0217-00L Process Engineering Ia

W 3 credits 2G E. Morgenroth

Abstract

Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

Objective

Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

Content

Stoichiometry
Microbial transformation processes
Introduction to design and modeling of activated sludge processes
Anaerobic processes, industrial applications, sludge stabilization

Literature

There will be a textbook that students need to purchase (see http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html for further information).

Prerequisites / notice

For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html

Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

EM: Waste Management

Elective Module for Majors "River and Hydraulic Engineering" "Urban Water Management" and "Water Resources Management".

Remark: 102-0337-00 Landfilling, Contaminated Sites and Radioactive Waste Repositories only for those students also taking module "System Analysis in Urban Water Management" as replacement of 102-0217-00 Process Engineering Ia in module "Waste Management".
**Abstract**

Biological processes used in wastewater treatment, organic waste management, biological resource recovery. Focus on fundamental principles of biological processes and process design based on kinetic and stoichiometric principles. Processes include anaerobic digestion for biogas production and aerobic wastewater treatment.

**Objective**

Students should be able to evaluate and design biological processes. Develop simple mathematical models to simulate treatment processes.

**Content**

- Stoichiometry
- Microbial transformation processes
- Introduction to design and modeling of activated sludge processes
- Anaerobic processes, industrial applications, sludge stabilization

**Literature**

There will be a textbook that students need to purchase (see [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html) for further information).

**Prerequisites / notice**

For detailed information on prerequisites the student should consult the lecture program and important information (syllabus) of Process Engineering Ia that can be downloaded at [http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html](http://www.sww.ifu.ethz.ch/education/lectures/process-engineering-ia.html).

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- **Social Competencies**
  - Communication: not assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed

- **Personal Competencies**
  - Adaptable and Flexibility: not assessed
  - Creative Thinking: not assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

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**102-0337-00L Landfilling, Contaminated Sites and Radioactive Waste Repositories**

- **W**
- **3 credits**
- **2G**
- **M. Plötze, W. Hummel**

**Abstract**

Practices of landfilling and remediation of contaminated sites and disposal of radioactive waste are based on the same concepts that aim to protect the environment. The assessment of contaminants that may leach into the environment as a function of time and how to reduce the rate of their release is key to the design of chemical, technical and geological barriers.

**Objective**

Upon successful completion of this course students are able to:
- assess the risk posed to the environment of landfills, contaminated sites and radioactive waste repositories in terms of fate and transport of contaminants
- describe technologies available to minimize environmental contamination
- describe the principles in handling of contaminated sites and to propose and evaluate suitable remediation techniques
- explain the concepts that underlie radioactive waste disposal practices.

**Content**

This lecture course comprises of lectures with exercises and guided case studies.
- A short overview of the principles of environmental protection in waste management and how this is applied in legislation.
- An overview of the chemistry underlying the release and transport of contaminants from the landfilled/contaminated material/radioactive waste repository focusing on processes that control redox state and pH buffer capacity, mobility of heavy metals and organic compounds
- Technical barrier design and function. Clay as a barrier.
- Contaminated site remediation: Site evaluation, remediation technologies
- Concepts and safety in radioactive waste management
- Role of the geological and engineered barriers and radionuclide transport in geological media.

**Literature**

Literature will be made available.

---
By the end of the course, you should be able to do the following:

Waste Recycling Technology (WRT) is a sub-discipline of Mechanical Process Engineering. WRT is employed in production plants but also of how these unit operations are integrated into the flow sheets of production plants.

A list of recommended books will be provided.

In this course, the students learn modern urban drainage engineering approaches, critical thinking, decision making in a complex environment as well as dealing with insufficient data and ill-defined problems.

The topics cover:
- Integrated urban water management
- Hydrological and hydrodynamic modelling
- Water quality based assessment
- Freshwater ecology
- Hydraulic capacity assessment
- Sewer network operation
- Decision analysis
ECTS: 6

Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).

Objective: The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.

Content: The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.

Prerequisites: Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences). Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).

Literature: Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.

Prerequisites / notice
Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td>Method-specific Competencies</td>
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<td>assessed</td>
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<td></td>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
<td>assessed</td>
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<tr>
<td>Social Competencies</td>
<td>Communication</td>
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<td></td>
<td>Cooperation and Teamwork</td>
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<td>Personal Competencies</td>
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<td></td>
<td>Creative Thinking</td>
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<td></td>
<td>Critical Thinking</td>
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<td></td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
</table>

Specialized Computer Laboratory

Experimental and Computer Laboratory I (Year Course)  ■

Abstract: In the Experimental and Computer Laboratory students are introduced to research and good scientific practice. Experiments are conducted in different disciplines of environmental engineering. Data collected during experiments are compared to the corresponding numeric simulations. The results are documented in reports or presentations.

Objective: The student will learn the following skills: basic scientific work, planning and conducting scientific experiments, uncertainty estimations of measurements, applied numerical simulations, modern sensor technology, writing reports.
Content
The Experimental and Computer Laboratory is building on courses in the corresponding modules. Material from these courses is a prerequisite or co-requisite (as specified below) for participating in the Experimental and Computer Laboratory (MODULE: Project in the Experimental and Computer Laboratory):
- WatInfra: Water Network Management
- UWM: SysUWM + ProcUWM: Operation of Lab-WWTP
- AIR: Air Quality Measurements
- WasteBio: Anaerobic Digestion
- WasteRec: Plastic Recycling
- ESD: Environmental Assessment
- GROUND: Groundwater Field Course Kappelen
- WRM: Modelling Optimal Water Allocation
- FLOW: 1D Open Channel Flow Modelling
- LAND: Landscape Planning and Environmental Systems
- RIVER: Discharge Measurements
- RemSens: Earth Observation and Landscape Planning
- SOIL: Soil and Environmental Measurements Lab

Lecture notes
Written material will be available.

103-0347-70L Supplementary Course to Project LAND within Experimental and Computer Lab. I
Only for Environmental Sciences MSc.

W 1 credit 1U D. Braun

This is a supplementary course for students in the Laboratory Courses in Environmental Engineering who wish to complete all the exercises in Landscape planning and environmental system, as in the 3CP course 103-0347-01L Landscape Planning and Environmental Systems (GIS Exercises).

Abstract
Supplement course to Project LAND in the Experimental and Computer Lab.
Methods for the identification and measurement of landscape structure, changes, functions and services, as well as measures and implementation of landscape planning are deepened.

Elctives
The entire course programs of ETH Zurich and the University of Zurich are open to the students to individual selection.

Course Catalogue of ETH Zurich

Master’s Thesis
The Master Programme concludes with the Master Thesis, which has to be done in one of the chosen Majors and has to be completed within 28 weeks. The Master Thesis is supervised by a professor and shall attest the students ability to work independently and to produce scientifically structured work.

Number Title Type ECTS Hours Lecturers
102-0010-01L Master's Thesis W 30 credits 64D Supervisors

Science in Perspective
see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-BAUG

Course Units for Additional Admission Requirements
The courses below are only available for MSc students with additional admission requirements.

Number Title Type ECTS Hours Lecturers
101-0203-AAL Hydraulics I E- 5 credits 11R R. Stocker

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.

Objective
Familiarization with the basics of hydromechanics of steady state flows

Content
Properties of water, hydrostatics, continuity. Euler equation of motion, Navier Stokes equation, similarity, Bernoulli principle, momentum equation for finite volumes, potential flows, ideal fluids-real fluids, boundary layer, pipe flow, open channel flow, flow in porous media, flow measurements, demonstration experiments in the lecture hall and in the laboratory

Lecture notes
Script and collection of problems available

Literature
Bollrich, Technische Hydromechanik 1, Verlag Bauwesen, Berlin

102-0214-AAL Introduction to Urban Water Management E- 6 credits 13R E. Morgenroth, M. Maurer

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Introduction to urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). Introduction to Urban Water Management is a self-study course.

**Objective**

This course provides an introduction and an overview over the topics of urban water management (water supply, urban drainage, wastewater treatment, sewage sludge treatment). It supports the understanding of the interactions of the relevant technical and natural systems. Simple design models are introduced.

**Content**

Overview over the field of urban water management.
- Introduction into systems analysis.
- Characterization of water and water quality.
- Requirement of drinking water, production of wastewater and pollutants.
- Production and supply of drinking water.
- Urban drainage, treatment of combined sewer overflow.
- Wastewater treatment, nutrient elimination, sludge handling.
- Planning of urban water infrastructure.

**Lecture notes**

Water Supply and Pollution Control. 8th edition (2009).
By: Warren Viessman, Jr., Mark J. Hammer, Elizabeth M. Perez and Paul A. Chadik.
Pearson Prentice Hall, Upper Saddle River, NJ.

**Literature**

In this self-study course the students must work through and understand selected sections from the following book.


Students must understand and be able to discuss the required reading in a 30 min oral exam. The required reading is explained in detail on the website of the professorships of urban water management. Additional information can be asked during the office hours of the professors' assistants.

The required reading and studying should correspond roughly the time invested in the course Siedlungswasserwirtschaft GZ. Students are welcome to ask the assistants (http://www.sww.ifu.ethz.ch/group/teaching-assistants.html) for help with questions they have regarding the reading.

**Prerequisites / notice**

Some students joining the MSc program in Environmental Engineering at ETH Zürich have to take additional courses from our BSc program. The decision of what courses to take is done at the time of admission at ETH.

The course on "Introduction to Urban Water Management" is offered at ETH Zürich only in German. Students who can speak and understand German must take the course (Siedlungswasserwirtschaft GZ) and get a passing grade. For students that do not have sufficient German language skills there is a self-study course and they have to take an oral exam.

This course is required for further in-depth courses in urban water management.

**Prerequisite:** Hydraulics I and Hydrology

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Reading</th>
</tr>
</thead>
</table>

**Abstract**

Methodological basics and application of various environmental assessment tools.

**Objective**

Students learn about environmental assessment tools, such as material flow analysis, risk assessment, and life cycle assessment. They can identify and apply the appropriate tool in a given situation. Also, they are able to critically assess existing studies.

**Content**

- Methodological basics of material flow analysis, risk assessment and life cycle assessment
- Application of these methods to case studies

**Lecture notes**

No script, but literature available on moodle

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<table>
<thead>
<tr>
<th>Course Code</th>
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<th>Credits</th>
<th>Reading</th>
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</table>

**Abstract**

Introduction into the problems of waste handling with the goal to get the ability of seeing and improving the influence of commodities and products with there packaging to the environment - as they are becoming waste. Knowing the different mechanical and chemical processes, which are applicable in the field of waste management.

**Objective**

In the course "Waste Management", the competencies of process understanding, system understanding, modeling, concept development, measurement methods and data analysis & interpretation are taught. The competencies process understanding and system understanding are applied and examined in addition. Concept development is also examined.

**Content**

This lecture gives a comprehensive overview of the different waste-types and waste handling possibilities:
- Waste composition as a mirror of the human evolution
- Waste definition (formation, amount, energy content, waste composition)
- Several recycling possibilities and processes
- Thermal waste treatment (electricity/district heat as products), including off-gas cleaning and incineration residue handling with regards to the final residue storage in a landfill and the problems which have to be solved there
- Special fields like biological waste handling (composting, fermentation), handling of special wastes and municipal sewage sludge treatment
- Economical aspects

**Lecture notes**

Martin F. Lemann, Christoph Leitzinger, Leo S. Morf: Waste Management
Edition 2020, 433 pages
ISBN 978-3-952597-0-6

**Literature**

Martin F. Lemann, Christoph Leitzinger, Leo S. Morf: Waste Management
Edition 2020, 433 pages
ISBN 978-3-952597-0-6

**Prerequisites / notice**

basic of chemical processes has to be known
Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility not assessed
- Creative Thinking not assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management not assessed

Groundwater I

<table>
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<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>ECTS</th>
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<tr>
<td>102-0455-AAL</td>
<td>Groundwater I</td>
<td>4</td>
<td>9R</td>
<td>J. Jimenez-Martinez, M. Willmann</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The course provides a quantitative introduction to groundwater flow and contaminant transport.

Objective
In “Groundwater I” the competencies of process understanding are taught, applied and examined. Furthermore, system understanding and concept development are taught and applied, which are previous steps to groundwater modeling. To add measurement methods are taught and data analysis & interpretation is applied during the course.

Content
- Properties of porous and fractured media
- Darcy’s law
- Flow equation
- Stream functions
- Interpretation of pumping tests
- Transport processes
- Transport equation
- Analytical solutions for transport
- Numerical methods: finite differences method
- Aquifers remediation
- Case studies

Literature
- W. Kinzelbach, R. Rausch, Grundwassermodellierung, Gebrüder Bornträger, Stuttgart, 1995

Air Pollution Control

<table>
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<tr>
<th>Code</th>
<th>Title</th>
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<tr>
<td>102-0635-AAL</td>
<td>Air Pollution Control</td>
<td>3</td>
<td>13R</td>
<td>J. Wang, B. Buchmann</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Abstract
The lecture provides an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and the impact on air quality. Theoretical description and modeling of these processes, air quality measurement techniques and pollution control techniques are covered.

Objective
The students gain general knowledge of the factors resulting in air pollution and the techniques used for air pollution control. The students can identify major air pollution sources and understand the methods for measurement, data collection and analysis. The students can evaluate possible control methods and equipment, design a control system and estimate the efficiency and cost.

Content
- Physical and chemical processes leading to emission of pollutants
- Air quality analysis
- Meteorological parameters influencing air pollution dispersion
- Deterministic and stochastic models, describing the air pollution dispersion
- Measurement concepts to observe ambient air pollution
- Removal of gaseous pollutants by absorption and adsorption
- Control of NOx and SOx
- Fundamentals of particulate control
- Design and application of wet scrubbers

Literature
Text book

Prerequisites / notice
College lectures on basic physics, chemistry and mathematics.
**Introduction to Water Resources Management**

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

The course offers an introduction to the basics of water resources analysis and management covering the topics of water demand vs availability, water exploitation and reservoir design, aquatic physics, water quality and pollution, water conservation and remediation in rivers, lakes and aquifers, sustainable water use.

**Objective**

Introduction to the basics of sustainable water resources management based on relevant hydrological processes, management approaches and mathematical models.

**Content**


Example of application of modelling techniques are made available on selected topics. Four computer-based class exercises on selected topics are offered and guided through teaching assistants.

**Lecture notes**

Handouts of slides and additional reading material are provided on the Moodle course webpage (https://moodle-app2.let.ethz.ch/course/view.php?id=14738)

**Literature**

Literature information is provided either in the handouts or on the Moodle course webpage (https://moodle-app2.let.ethz.ch/course/view.php?id=14738)

**Prerequisites / notice**

Knowledge from the course “Hydrology” (3rd semester Environmental Engineering) and about basic statistics and probability theory is a prerequisite (not formal).

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: not assessed

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- **Personal Competencies**
  - Adaptability and Flexibility: assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: assessed

**Computer Science II**

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

**Abstract**

Introduction to programming in Java. Procedural foundations of programming and outlook to object oriented programming. Variables, types, assignments, control structures (branch, loop), data structures, algorithms, line graphics, graphical user interface. Writing small programs. Working with a professional programming environment (Eclipse).

**Objective**

In the course “Computer Science II”, the competencies of programming, modeling and data analysis & interpretation are taught, applied and examined. The students will be able to write simple programs and to modify existing programs.

**Content**

This course offers an introduction to variables, control structures (branch, loop), algorithms and data structures, as well as an outlook to modularisation and object oriented techniques. In the exercises students train programming skills (in the programming language JAVA). Students can solve the exercises on their own laptop or in the computer labs at ETH. The software used in this course runs on MS Windows, MacOS X and Linux.

**Prerequisites / notice**

Prerequisites:

- 252-0845-00 Computer Science I (D-BAUG)

**Chemistry I and II**

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
General Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature
Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

529-2002-AAL Chemistry II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Chemistry II: Redox reactions, chemistry of the elements, introduction to organic chemistry

Objective
Erweitern der allgemeinen Grundlagen und Erarbeiten einer Basis, um Prozesse in komplexeren Umweltsystemen (Wasser / Luft / Boden) in ihrem zeitlichen und quantitativen Ablauf verstehen und beurteilen zu können.

Content
1. Redoxreactions
2. Inorganic Chemistry
   Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.
3. Introduction to organic chemistry
   Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups.
   Stereocchemistry.
   Reaction mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds). Chemistry of carbony and carboxyl groups.
   Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronoc structure of the elements.

Lecture notes

Literature
### Biochemistry

**752-0100-AAL**

**Biochemistry**

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

*Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.*

**Abstract**

Basic knowledge of enzymology, in particular the structure, kinetics and chemistry of enzyme-catalysed reaction in vitro and in vivo. Biochemistry of metabolism: Those completing the course are able to describe and understand fundamental cellular metabolic processes.

**Objective**

Based on the biology and chemistry courses in the 1. and 2. semester more detailed biochemical knowledge about enzymology, membrane biochemistry, and central metabolism will be presented.

**Content**

- Introduction, basics, composition of cells, biochemical units, repetition of relevant organic chemistry
- Structure and function of proteins
- Carbohydrates, structure of DNA
- Enzymes and enzyme kinetics
- Catalytic strategies
- Metabolism: Basic concepts and design. Repetition of basic thermodynamics
- Glycolysis
- The citric acid cycle
- Oxidative phosphorylation
- Fatty acid metabolism

**Lecture notes**


**Literature**


**Prerequisites / notice**

Basic knowledge in biology and chemistry is a precondition.

**Fostered competencies**

**Subject-specific Competencies**

- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**

- Analytical Competencies: not assessed
- Decision-making: assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

**Social Competencies**

- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: not assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

**Personal Competencies**

- Adaptability and Flexibility: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: assessed

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### Microbiology

**752-4001-AAL**

**Microbiology**

**Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.**

*Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.*

**Abstract**

Self-study course in microbiology.

**Data:** 01.11.2022 12:41  
**Autumn Semester 2022**  
**Page 2187 of 2416**
This self-study course is based on the book ‘Brock, Biology of Microorganisms’.

**102-0293-AAL Hydrology**

| Objective | Teaching of basic knowledge in microbiology. |
| Content  | This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology. |
| Literature | This self-study course is based on the book ‘Brock, Biology of Microorganisms’. |
| Literature | Teaching of basic knowledge in microbiology. |
| Literature | Hydrology |
| Literature | Der hydrologische Kreislauf: globale Wasserressourcen, Wasserbilanz, räumliche und zeitliche Dimension der hydrologischen Prozesse. |
| Literature | This self-study course is based on the book ‘Brock, Biology of Microorganisms’. |
| Literature | Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit. |
| Objective | Kenntnis der Grundzüge der Hydrologie. Kennenlernen von Methoden, zur Abschätzung hydrologischer Grössen, die zur Dimensionierung von Wasserbauwerken und für die Nutzung von Wasserressourcen relevant sind. |
| Content  | Der hydrologische Kreislauf: globale Wasserressourcen, Wasserbilanz, räumliche und zeitliche Dimension der hydrologischen Prozesse. |
| Interception: Messung und Schätzung. |
| Evaporation and Evapotranspiration: Prozesse, Messung und Schätzung, potentielle und effektive Evapotranspiration, Energiebilanzmethode, empirische Methoden. |
| Infiltration: Messung, Horton-Gleichung, empirische und konzeptionelle Methoden, F-index and Prozente Analyse, SCS-CN Methode. |
| Einzugsgebietscharakteristik: Morphologie des Einzugsgebietes, topografische und unterirdische Wasserscheide, hypsometrische Kurve, Gefälle, Dichte des Entwässerungsnets. |
| Schnee und Eis: Schneeeigenschaften und -messungen Schätzung des Schneeschmelzprozesses durch die Energiebilanzmethode, Abfluss aus Schneeschmelze, Temperatur-Index- und Grad-Tag-Verfahren. |
| Lecture notes | Ein internes Skript ist zur Verfügung (kostenpflichtig, nur Herstellungskosten) |
| Literature | Die Kopie der Folien zur Vorlesung können auf den Webseiten der Professur für Hydrologie und Wasserwirtschaft heruntergeladen werden. |
| Prerequisites / notice | Vorbereitend zu Hydrologie I sind die Vorlesungen in Statistik. Der Inhalt, der um ein Teil der Übungen zu behandeln und um ein Teil der Vorlesungen zu verstehen notwendig ist, kann zusammengefasst werden, wie hintereinander es beschrieben wird: |
| Prerequisites / notice | Elementarere Datenverarbeitung: Hydrologische Messungen und Daten, Datenreduzierung (grafische Darstellungen und numerische Kenngrössen). |
| 406-0023-AAL Physics** | Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. |
| Objective | The goal of this course is to make students able to explain and apply the basic principles and methodology of physics to problems of interest in modern science and engineering. An important component of this is learning how to solve new, complex problems by breaking them down into parts and applying approximations. |
| Content | Oscillations and waves in matter |
| Content | Thermodynamics (temperature, heat, equations of state, laws of thermodynamics, entropy, transport) |
| Content | Electromagnetism (electrostatics, magnetostatics, circuits, Maxwell's equations, electromagnetic waves, induction, electromagnetic properties of materials) |
| Content | Overview of quantum and atomic physics |
| Literature | Introduction to special relativity |
| Literature | Lecture notes and exercise sheets will be distributed via Moodle. |
### Stochastics (Probability and Statistics)

**406-0603-AAL**  
Stochastics (Probability and Statistics)  
E-4 credits  9R  M. Kalisch

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement. Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.*

**Abstract**  
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

**Objective**  
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language “R”.

**Content**  
From “Statistics for research” (online)  
Ch 1: The Role of Statistics  
Ch 2: Populations, Samples, and Probability Distributions  
Ch 3: Binomial Distributions  
Ch 6: Sampling Distribution of Averages  
Ch 7: Normal Distributions  
Ch 8: Student's t Distribution  
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"  
Ch 1: Basics  
Ch 2: The R Environment  
Ch 3: Probability and distributions  
Ch 4: Descriptive statistics and tables  
Ch 5: One- and two-sample tests  
Ch 6: Regression and correlation

**Literature**  
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435  
From within the ETH, this book is freely available online under:  

From within the ETH, this book is freely available online under:  
http://www.springerlink.com/content/m17578/

### Linear Algebra

**406-0141-AAL**  
Linear Algebra  
E-5 credits  11R  M. Akka Ginosar

*Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.*

**Abstract**  
Introduction to Linear Algebra and Numerical Analysis for Engineers. This reading course is based on chapters from the book “Introduction to Linear Algebra” by Gilbert Strang (SIAM 2009), and “A first Course in Numerical Methods” by U. Ascher and C. Greif (SIAM, 2011).

**Objective**  
To acquire basic knowledge of Linear Algebra and some aspects of related numerical methods and the ability to apply basic algorithms to simple problems.
1 Introduction, calculations using MATLAB
2 Linear systems I
3 Linear systems II
4 Scalar- & vektorproduct
5 Basics of matrix algebra
6 Linear maps
7 Orthogonal maps
8 Trace & determinant
9 General vectorspaces
10 Metric & scalarproducts
11 Basis, basistransform & similar matrices
12 Eigenvalues & eigenvectors
13 Spectral theorem & diagonalisation
14 Repetition

Content

Literature

Prerequisites / notice
Knowledge of elementary calculus

Abstract
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Objective
Mathematics as a tool to solve engineering problems, mathematical formulation of problems in science and engineering. Basic mathematical knowledge of an engineers.

Content

Literature
Textbooks in English:
- J. Stewart: Multivariable Calculus, Thomson Brooks/Cole
- V. I. Smirnov: A course of higher mathematics. Vol. II. Advanced calculus
- M. Akveld, R. Sperb, Analysis II, vdf
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

Abstract
Mathematical tools of an engineer

Objective
Mathematics as a tool to solve engineering problems, mathematical formulation of technical and scientific problems. Basic mathematical knowledge for engineers.

Content
Complex numbers.
Calculus for functions of one variable with applications.
Simple Mathematical models in engineering.

Literature
Textbooks in English:
- M. Akveld, R. Sperb: Analysis I, vdf
- M. Akveld, R. Sperb: Analysis II, vdf
- L. Papula: Mathematik für Ingenieure und Naturwissenschaftler, Vieweg Verlag
- L. Papula: Mathematik für Ingenieure 2, Vieweg Verlag

Environmental Engineering Master - Key for Type

O Compulsory
W+ Eligible for credits and recommended
W Eligible for credits
X- Recommended, not eligible for credits
Z Courses outside the curriculum
Dr Suitable for doctorate

Key for Hours
V lecture
G lecture with exercise
U exercise
S seminar
K colloquium
P practical/laboratory course
A independent project
D diploma thesis
R revision course / private study

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.
The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-00L</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

Abstract: This course looks into scientific theories and also empirical studies on human learning and relates them to the school.

Objective: Anyone wishing to be a successful teacher must first of all understand the learning process. Against this background, theories and findings on the way humans process information and on human behaviour are prepared in such a manner that they can be used for planning and conducting lessons. Students additionally gain an understanding of what is going on in learning and behavioural research so that teachers are put in a position where they can further educate themselves in the field of research into teaching and learning.

Content: The successful participation in EW1 ("Human Learning") and EW2 ("Designing Learning Environments for School") is recommended, but not a mandatory prerequisite.

Prerequisites / notice: This lecture is only apt for students who intend to enrol in the programs "Lehrdiplom" or "Didaktisches Zertifikat". It is about learning in childhood and adolescence.

<table>
<thead>
<tr>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-06L</td>
<td>W</td>
<td>2</td>
<td>2S</td>
<td>R. Schumacher</td>
</tr>
</tbody>
</table>

Abstract: This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective: - Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice: This course unit can only be enrolled after successful participation in the course "Human Learning (EW 1)".

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
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<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0242-07L</td>
<td>W</td>
<td>1</td>
<td>1S</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

Abstract: The focus will be on the book "Intelligenz: Grosse Unterschiede und ihre Folgen" by Stern and Neubauer. Participation at the first meeting is obligatory. It is required that all participants read the complete book. Furthermore, in two meetings of 90 minutes, concept papers developed in small groups (5 - 10 students) will be discussed.

Objective: - Understanding of research methods used in the empirical human sciences
- Getting to know intelligence tests
- Understanding findings relevant for education

<table>
<thead>
<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-08L</td>
<td>W</td>
<td>1</td>
<td>2S</td>
<td>C. M. Thurn, P. Edelsbrunner</td>
</tr>
</tbody>
</table>

Abstract: Literature from the learning sciences is critically discussed with a focus on research methods. At the first meeting, working groups will be assembled and meetings with those will be set up. In the small groups students will write critical essays about the read literature. At the third meeting, we will discuss the essays and develop research questions in group work.

Objective: - Understand research methods used in the empirical educational sciences
- Understand and critically examine information from scientific journals and media
- Understand pedagogically relevant findings from the empirical educational sciences

<table>
<thead>
<tr>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0240-22L</td>
<td>W</td>
<td>2</td>
<td>3S</td>
<td>U. Markwalder, S. Maurer, S. Peteranderl-Rüschoff</td>
</tr>
</tbody>
</table>

Abstract: This seminar focuses on teaching units in chemistry, physics and mathematics that have been developed at the MINT Learning Center of the ETH Zurich. In the first meeting, the mission of the MINT Learning Center will be communicated. Furthermore, in groups of two, the students will intensively work on, refine and optimize a teaching unit following a goal set in advance.

Objective: - Get to know cognitively activating instructions in MINT subjects
- Get information about recent literature on learning and instruction

Prerequisites / notice: This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

<table>
<thead>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0242-09L</td>
<td>O</td>
<td>2</td>
<td>2V</td>
<td>E. Stern</td>
</tr>
</tbody>
</table>

Abstract: This course unit can only be enrolled after successful participation in, or during enrollment in the course "Human Learning (EW 1)".

Objective: - Understanding findings relevant for education
- Understanding pedagogically relevant findings from the empirical educational sciences
In this class, students will learn concepts and skills for coping with psychosocial demands of teaching.

Students possess theoretical knowledge and practical competences to be able to cope with the psychosocial demands of teaching.

- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues.
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

**Gender Issues In Education and STEM**  
**Number of participants limited to 30.**

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

**Formation of Knowledge in STEM Fields in Primary and Secondary School**

Adresses to students enrolled either in Teaching Diploma* (TD) or Teaching Certificate (TC) (excluding Teaching Diploma Sport).

This course unit can only be enroled after successful participation in the course 851-0240-00L "Human Learning (EW 1)".

- To familiarize students with gender issues in the educational and STEM context and with controversies regarding these issues.
- To develop a critical view on existing research and perspectives.
- To integrate this knowledge with teacher’s work.

**Environmental Education Didactics I**

Enrolment only possible with matriculation in Teaching Diploma or Teaching Certificate (excluding Teaching Diploma Sport).

The event includes a block seminar as well as an assistance period in a primary or secondary school. It is part of a project with the goal of helping teachers in adapting their teaching methods flexibly to the needs of students from lower grades.

In this class, students will learn concepts and skills for coping with psychosocial demands of teaching.

Prerequisite: students should be taking the course 851-0240-00L Human Learning (EW1) in parallel, or to have successfully completed it.

Prerequisite: Successful participation in the course 851-0240-00L Human Learning (EW1).

**Teaching Internship Including Examination Lessons**

Prerequisite: successful participation in Mentored Assignment (701-0822-00L).

Repetition of the Teaching Internship is excluded even if Examination Lessons are to be repeated.

Students apply the insights, abilities and skills they have acquired within the context of an educational institution. They observe 10 lessons and teach 20 lessons independently. Two of them are as assessed as Examination Lessons.
Objective
- Students use their specialist-subject, educational-science and subject-didactics training to draw up concepts for teaching.
- They are able to assess the significance of tuition topics for their subject from different angles (including interdisciplinary angles) and impart these to their pupils.
- They learn the skills of the teaching trade.
- They practise finding the balance between instruction and openness so that pupils can and, indeed, must make their own cognitive contribution.
- They learn to assess pupils' work.
- Together with the teacher in charge of their teacher training, the students constantly evaluate their own performance.

Content
The students will be able to watch and evaluate the teaching of colleagues and experts. They get profit out of their teaching experiences not only when preparing but also when teaching. Doing so they will be supported by their mentors. Two lessons of the course will be split off for the examination - procedure.

Lecture notes
Dokumente unter
https://www.ethz.ch/de/studium/didaktische-ausbildung/studienangebot-zulassung/didaktik-zertifikat/dokumente--didaktik-zertifikat-.html
- Raster zum Bericht über das Unterrichtspraktikum im DZ Umweltlehre an der ETH Zürich (PDF)
- Beurteilungsbogen Prüfungslektionen Umweltlehre
- Schriftliche Unterrichtsvorbereitung für Prüfungslektionen (PDF)

Literature
Wird von der Praktikumslehrperson bestimmt.

Environmental Studies TC - Key for Type

| O   | Compulsory          | E-  | Recommended, not eligible for credits |
| W+  | Eligible for credits and recommended | Z   | Courses outside the curriculum       |
| W   | Eligible for credits | Dr  | Suitable for doctorate               |

Key for Hours

| V   | lecture            | P   | practical/laboratory course       |
| G   | lecture with exercise | A   | independent project               |
| U   | exercise            | D   | diploma thesis                    |
| S   | seminar             | R   | revision course / private study   |
| K   | colloquium          |     |                                  |

ECTS
European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Environmental Sciences Bachelor

Basic Courses I

First Year Examinations

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>529-2001-02L</td>
<td>Chemistry I</td>
<td>O</td>
<td>4 credits</td>
<td>2V+2U</td>
<td>J. Cvengros, J. E. E. Buschmann, P. Funck, E. C. Meister, R. Verel</td>
</tr>
</tbody>
</table>

Abstract

General Chemistry I: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium.

In the course “Chemistry I”, the competencies of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught, applied and examined.

Objective

Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physical-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content

1. Stoichiometry
   Amount of substance and mass. Composition of chemical compounds. Reaction equation. Ideal gas law.
2. Atoms
   Elementary particles and atoms. Electron configuration of the elements. Periodic system.
4. Basics of chemical thermodynamics
   System and surroundings. Description of state and change of state of chemical systems.
5. First law of thermodynamics
6. Second law of thermodynamics
   Entropy. Change of entropy in chemical systems and universe. Reaction entropy.
7. Gibbs energy and chemical potential.
8. Chemical equilibrium
   Law of mass action. Reaction quotient and equilibrium constant. Phase transition equilibrium.
9. Acids and bases
10. Dissolution and precipitation.
    Heterogeneous equilibrium. Dissolution and solubility product. Carbon dioxide-carbonic acid-carbonate equilibrium.

Lecture notes

Online-Skript mit durchgerechneten Beispielen.

Literature


Weiterführende Literatur:


Fostered competencies

Subject-specific Competencies

- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies

- Analytical Competencies assessed
- Decision-making assessed
- Media and Digital Technologies not assessed
- Problem-solving assessed
- Project Management not assessed

Social Competencies

- Communication not assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence not assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies

- Adaptability and Flexibility not assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics not assessed
- Self-awareness and Self-reflection not assessed
- Self-direction and Self-management assessed

401-0251-00L Mathematics I O 6 credits 4V+2U A. Cannas da Silva

Abstract

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Objective

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of both of these courses.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2194 of 2416
In the first semester the students compile what is known about the case topic, its principles and challenges. Each group of students makes

Students are able:
- carry out research on a given topic and present the results in a structured report which (a) shows the state of knowledge and (b) the need for knowledge and action (UPL I).
- to integrate knowledge of diverse perspectives in a qualitative systems model, to identify problems and to suggest possible solutions from a specific stakeholder's perspective (UPL II).
- name the different roles within a group, explain the role(s) they are suited for, self-organise in groups, identify problems of collaboration and constructively address the problems (UPL I and II).

Content
In the first semester the students compile what is known about the case topic, its principles and challenges. Each group of students makes an inquiry to a given part of the overall problem. The inquiry includes a thematic as well as stakeholder analysis. The results are written in a report and presented at an internal conference.

During synthesis week, which takes place during semester break, the results of the different part inquiries are integrated in a qualitative system model. The students identify specific problems and develop solutions.

In the second semester, students work independently and in exchange with stakeholders on previously identified problems. They develop a sustainability project with concrete measures that they could implement voluntarily in the third semester. The course concludes with the presentation of the student projects on the "Market of Measures".

501-0001-00L 701-0007-00L

Tackling Environmental Problems I Tackling Environmental Problems I

Only for Environmental Sciences BSc. Only for Environmental Sciences BSc.

Abstract
Each year in the case study we analyse a different topic from the field of sustainable development and develop solutions to it.

Objective
Students are able:
- The overall topic of the case study (by external experts),
- Inquiry, scientific writing and managing references (by experts of ETH library),
- Role behaviour and collaboration in groups,
- Preparing reports, posters and presentations,
- Qualitative system modelling (SystemQ),
- Developing solutions (design thinking, Checklands' soft systems methodology, sustainability assessment).

Content
In the first semester the students compile what is known about the case topic, its principles and challenges. Each group of students makes an inquiry to a given part of the overall problem. The inquiry includes a thematic as well as stakeholder analysis. The results are written in a report and presented at an internal conference.

During synthesis week, which takes place during semester break, the results of the different part inquiries are integrated in a qualitative system model. The students identify specific problems and develop solutions.

In the second semester, students work independently and in exchange with stakeholders on previously identified problems. They develop a sustainability project with concrete measures that they could implement voluntarily in the third semester. The course concludes with the presentation of the student projects on the "Market of Measures".

551-0001-00L 551-0001-00L

Organismic Biology I Organismic Biology I

Abstract
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny. First in a series of two lectures given over two semesters for students of agricultural and food sciences, as well as of environmental sciences.

Objective
The understanding of some basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Content
Week 1-7 by Alex Widmer, Chapters 12-25
- Cell biology
- Mitosis
- Genetics
- Sexual life cycles and meiosis
- Genetics
- Mendelian genetics
- Genetics
- Linkage and chromosomes
- Genetics
- Evolution of genomes
- Evolution
- How evolution works
- Evolution
- Phylogenetic reconstructions
- Evolution
- Microevolution
- Evolution
- Species and speciation
- Evolution
- Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
- Diversity of Life
- Introduction to viruses
- Diversity of Life
- Prokaryotes
- Diversity of Life
- Origin & evolution of eukaryotes
- Diversity of Life
- Nonvascular&seedless vascular plants
- Diversity of Life
- Seed plants
- Diversity of Life
- Introduction to fungi
- Diversity of Life
- Overview of animal diversity
- Diversity of Life
- Introduction to invertebrates
- Diversity of Life
- Origin & evolution of vertebrates

Lecture notes
Tutors will compile the case study dossier on the basis of the student reports.

Literature
Methodological documentation will be made available on Moodle during the case study together with the relevant background literature.

Prerequisites / notice
Prerequisites: familiarity with the basic notions from Calculus, in particular those of function and derivative.
The lecture is the first in a series of two lectures given over two semesters for students with biology as a basic subject.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0243-01L</td>
<td>Biology III: Essentials of Ecology</td>
<td>O</td>
<td>3</td>
<td>2V</td>
<td>C. Buser Moser</td>
</tr>
<tr>
<td>Abstract</td>
<td>This introductory lecture in ecology covers basic ecological concepts and the most important levels of complexity in ecological research. Ecological concepts are exemplified by using aquatic and terrestrial systems; corresponding methodological approaches are demonstrated. Threats to biodiversity and the appropriate management are discussed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>The objective of this lecture is to teach basic ecological concepts and the different levels of complexity in ecological research. The students should learn ecological concepts at these different levels in the context of concrete examples from terrestrial and aquatic ecology. Corresponding methods for studying the systems will be presented. A further aim of the lecture is that students achieve an understanding of biodiversity, why it is threatened and how it can be managed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Content    | - Einfluss von Umweltfaktoren (Temperatur, Strahlung, Wasser, Nährstoffe etc.) auf Organismen; Anpassung an bestimmte Umweltbedingungen  
- Populationsdynamik: Ursachen, Beschreibung, Vorhersage und Regulation  
- Interaktionen zwischen Arten (Konkurrenz, Koexistenz, Prädation, Parasitismus, Nahrungsnetze)  
- Lebensgemeinschaften: Struktur, Stabilität, Sukzession  
- Ökosysteme: Kompartimente, Stoff- und Energieflüsse  
- Biodiversität: Variation, Ursachen, Gefährdung und Erhaltung  
- Aktuelle Naturschutzprobleme und -massnahmen  
- Evolutionäre Ökologie: Methodik, Spezialisierung, Koevolution |      |      |       |                     |
| Literature | Underlagen, Vorlesungsfolien und relevante Literatur sind in Moodle abrufbar. Die Unterlagen für die nächste Vorlesung stehen jeweils spätestens am Freitagmorgen zur Verfügung. |      |      |       |                     |
| 701-0027-00L | Environmental Systems I | O    | 2    | 2V    | C. Schär, N. Dubois, G. Velicer |
| Abstract   | The lecture provides a science-based exploration of environmental aspects from three research fields: earth, climate, and health sciences. The students are able to explain important properties of the three environmental systems, to discuss critical drivers, trends and conflicts of their use, and to compare potential solutions. |      |      |       |                     |
| Objective  | The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of raw materials and fossil fuels, climate change and its impacts on man and environment, and the spread and control of infectious diseases in the human population and agricultural systems. |      |      |       |                     |
| Content    | Aquatic ecosystems and their function, water use and its impact, water pollution and water treatment, water and health, water technologies, water & energy. Forests and agroforest systems, trends and drivers of land use changes, sustainable forest management. |      |      |       |                     |
| Literature | Slides are provided by instructors and are accessible via moodle. |      |      |       |                     |
| 701-0029-00L | Environmental Systems II | O    | 3    | 2V    | A. Patt, H. Bugmann, N. Gruber |
| Abstract   | The lecture provides a science-based exploration of three important environmental systems: Inland waters, forest, and of food systems. The students are able to explain important functions of the three environmental systems, to discuss critical drivers, trends and conflicts of their use and to compare potential solutions. |      |      |       |                     |
| Objective  | The lecture discusses the role of the environmental systems based on selected environmental problems, among these the exploration of raw materials and fossil fuels, climate change and its impacts on man and environment, and the spread and control of infectious diseases in the human population and agricultural systems. |      |      |       |                     |
| Content    | Aquatic ecosystems and their function, water use and its impact, water pollution and water treatment, water and health, water technologies, water & energy. Forests and agroforest systems, trends and drivers of land use changes, sustainable forest management. |      |      |       |                     |
| Literature | Lecture notes or other documentation are provided by instructors and accessible via moodle. |      |      |       |                     |

#### Additional First Year Compulsory Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>252-0839-00L</td>
<td>Informatics</td>
<td>O</td>
<td>2G</td>
<td>2G</td>
<td>L. E. Fässler, M. Dahinden</td>
</tr>
<tr>
<td>Abstract</td>
<td>Students learn to apply selected concepts and tools from computer science for working on interdisciplinary projects. The following topics are covered: modeling and simulations, managing data with lists and tables and with relational databases, introduction to programming.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Objective</td>
<td>The students learn to</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- choose and apply appropriate tools from computer science,</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>- process and analyze real-world data from their subject of study,</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>- handle the complexity of real-world data.</td>
<td></td>
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</tr>
</tbody>
</table>
| Content    | 1. Modeling and simulations  
2. Data management with lists and tables  
3. Data management with a relational database  
4. Introduction to programming with Python |      |      |       |                     |
| Literature | All materials for the lecture are available at www.evim.ethz.ch |      |      |       |                     |
| Prerequisites / notice | This course is based on application-oriented learning. The students spend most of their time working through projects with data from natural science and discussing their results with teaching assistants. To learn the computer science basics there are electronic tutorials available. |      |      |       |                     |
Laboratory Course: Elementary Chemical Techniques

**Abstract**
This practical course provides an introduction to elementary laboratory techniques. The experiments cover a wide range of techniques, including analytical and synthetic techniques (e.g., investigation of soil and water samples or the preparation of simple compounds). Furthermore, the handling of gaseous substances is practised.

**Objective**
This course is intended to provide an overview of experimental chemical methods.

The handling of chemicals and proper laboratory techniques represent the main learning targets. Furthermore, the description and recording of laboratory processes is an essential part of this course.

**Content**
The classification and analysis of natural and artificial compounds is a key subject of this course. It provides an introduction to elementary laboratory techniques, and the experiments cover a wide range of analytic and synthetic tasks:

- Selected samples (e.g., soil and water) will be analysed with various methods, such as titrations, spectroscopy or ion chromatography. The chemistry of aqueous solutions (acid-base equilibria and solvation or precipitation processes) is studied.
- The synthesis of simple inorganic complexes or organic molecules is practised.
- Furthermore, the preparation and handling of environmentally relevant gaseous species like carbon dioxide or nitrogen oxides is a central subject of the Praktikum.

**Lecture notes**
The script will be published on the web.
Details will be provided on the first day of the semester.

**Literature**
A thorough study of all script materials is requested before the course starts.

**Prerequisites / notice**
Safety concept: https://chab.ethz.ch/studium/bachelor1.html

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Fundamentals of Microscopy and Plant Biology

**Abstract**

**Objective**
Capability of preparing biological specimen, microscopy and documentation. Understanding the correlation between plant structure and function at the level of organs, tissues and cells. Awareness of the link between plant anatomy, systematics, physiology, ecology, and development.

**Content**

**Lecture notes**
Handouts

**Literature**
For further reading (not obligatory):
Gerhard Wanner: Mikroskopisch-Botanisches Praktikum, Georg Thieme Verlag, Stuttgart.

**Prerequisites / notice**
Groups of a maximum of 30 students.

---

**Basic Courses II**

**Examination Blocks**

**Examination Block 1**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
402-0063-00L | Physics II | O | 5 credits | 3V+1U | A. Vaterlaus

**Abstract**
Introduction to the concepts and tools in Physics, with the help of demonstration experiments. The Chapters treated are Electromagnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena. Whenever possible, examples relevant to the students’ main field of study are given.

**Objective**
Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve them.

**Lecture notes**
A script will be distributed
Autumn Semester 2022

Fostered competencies

<table>
<thead>
<tr>
<th>Literature</th>
</tr>
</thead>
</table>
| Friedhelm Kuypers  
Physik für Ingenieure und Naturwissenschaftler  
Band 2 Elektrizität, Optik, Wellen  
Wiley-VCH, 2012  
ISBN 3527411445, 9783527411443 |
| Douglas C. Giancoli  
Physik  
3. erweiterte Auflage  
Pearson Studium |
| Hans J. Paus  
Physik in Experimenten und Beispielen  
Carl Hanser Verlag, München, 2002, 1068 S. |
| Paul A. Tipler  
Physik  
Spektrum Akademischer Verlag, 1998, 1522 S., ca Fr. 120.- |
| David Halliday, Robert Resnick, Jearl Walker  
Physik  
Wiley-VCH, 2003, 1388 S., Fr. 87.- (bis 31.12.03)  
dazu gratis Online Ressourcen (z.B. Simulationen): www.halliday.de |

Fostered competencies

Subject-specific Competencies

- Concepts and Theories: assessed

- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: not assessed

- Decision-making: not assessed

- Problem-solving: assessed

Social Competencies

- Communication: not assessed

752-4001-00L  
Microbiology  
O  2 credits  2V  M. Ackermann, M. Schuppler, J. Vorholt-Zambelli

Abstract  
Teaching of basic knowledge in microbiology with main focus on Microbial Cell Structure and Function, Molecular Genetics, Microbial Growth, Metabolic Diversity, Phylogeny and Taxonomy, Prokaryotic Diversity, Human-Microbe Interactions, Biotechnology.

Objective  
Teaching of basic knowledge in microbiology.

Content  

Lecture notes  
Wird von den jeweiligen Dozenten ausgegeben.

Literature  
Die Behandlung der Themen erfolgt auf der Basis des Lehrbuchs Brock, Biology of Microorganisms

401-0624-00L  
Mathematics IV: Statistics  
O  4 credits  2V+1U  J. Ernest

Abstract  
Introduction to basic methods and fundamental concepts of statistics and probability theory for practitioners in natural sciences. The concepts will be illustrated with some real data examples and applied using the statistical software R.

Objective  
Capacity to learn from data; good practice when dealing with data and recognizing possible fraud in statistics; basic knowledge about the laws of randomness and stochastic thinking (thinking in probabilities); application of simple methods in inferential statistics (e.g., several hypothesis tests will be introduced), i.a. also using the statistical software R. The lecture will be held in German.

Content  

Lecture notes  
Ausführliches Skript zur Vorlesung ist erhältlich.

Literature  

Prerequisites / notice  
Die Übungen (ca. die Hälfte der Kontaktstunden; einschließlich Computerübungen) sind ein wichtiger Bestandteil der Lehrveranstaltung.

Voraussetzungen: Mathematik I, II

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### Examination Block 2

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0071-00L</td>
<td>Mathematics III: Systems Analysis</td>
<td>O</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>C. Brunner, R. Knutti, S. Schemm, H. Wernli</td>
</tr>
</tbody>
</table>

Abstract  
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several variables, time-discrete models, and continuous models in time and space.

Objective  
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance. Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative approach - prediction.

Content  
https://iac.ethz.ch/edu/courses/bachelor/vorbereitung/systemanalyse.html

Lecture notes  
Overhead slides will be made available through the course website.

Literature  

Fostered competencies

Subject-specific Competencies

- Concepts and Theories: assessed

- Techniques and Technologies: assessed

Method-specific Competencies

- Analytical Competencies: assessed

- Problem-solving: assessed

Personal Competencies

- Creative Thinking: not assessed

- Critical Thinking: not assessed

701-0023-00L  
Atmosphere  
O  3 credits  2V  E. Fischer, T. Peter

---

Data: 01.11.2022 12:41  
Page 2198 of 2416
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between: weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.

Written information will be supplied.


701-0501-00L Pedosphere O 3 credits 2V R. Kretzschmar

Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties are explained and illustrated by numerous examples.

Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organisms, soil organic matter, soil formation, principles of soil classification, global soil regions, physical soil properties and functions, chemical soil properties and functions, soil fertility, land use and soil degradation.

Polybook


Prerequisites / notice

Prerequisites: Basic knowledge in chemistry, biology and geology.

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies

Analytical Competencies assessed
Problem-solving assessed

Additional Compulsory Courses

Number Title Type ECTS Hours Lecturers
701-0033-00L Laboratory Course in Physics for Students of Environmental Sciences O 2 credits 4P M. Männich, A. Biland, N. Gruber

Only students from 3rd Semester BSc Environmental Sciences on are admitted to this lecture.

Working in a laboratory forms an important part of modern scientific education. Using simple experimental setup the laboratory course will provide basic knowledge of:

- the setup of experiments,
- various measurement techniques,
- the use of various measurement instruments,
- the correct performance of experiments,
- the analysis of the accuracy of the measurements,
- and the interpretations of the measured quantities.

The course will also deepen the knowledge of experimental physics.

In addition to experiments selected from the physics lab for physicists, this lab course offers experiments specially developed for bachelor students in environmental sciences, which illustrate the mutual relationships between physical processes and chemical and biological phenomena.

The students select 4 out of 18 offered experiments which they like to perform. For each of these experiments the students document and analyze their measurements, estimate in written reports the accuracy of their results and compare these with the values expected according to the laws of physics.

Manuals for the experiments are provided online on the Moodle pages of the course.

Social Sciences and Humanities

Compulsory

Number Title Type ECTS Hours Lecturers
701-0707-00L Analysing Arguments in Science and Ethics O 2 credits 2G C. J. Baumberger

Number of Participants is limited to 160. Waiting list will be deleted 30.09.2022.

Problems of the environment and sustainable development are complex from a scientific as well as from an ethical point of view. Addressing them requires the ability to deal with arguments. This course provides basic knowledge and methods for reconstructing, analysing and evaluating arguments. We exercise and improve these abilities by using examples from science, ethics and political debates.

Students acquire basic knowledge and methods for analyzing arguments. They are able to apply these methods to complex arguments concerning scientific and ethical questions about the environment and sustainable development, and to construct themselves arguments and apply them successfully. Moreover, they are able to evaluate the contribution of arguments to controversial debates with the help of rules. Students acquire thereby a crucial skill for Critical Thinking, which aims at responsible argumentation, communication and action.
In the sciences as well as in public discussions or in our everyday life, we try to convince others or to achieve consent in matters of disagreement. We do this with the help of arguments. But what are the criteria for arguments to be convincing and for claims to be clear? How do we functionally feed arguments into a debate? How can we identify and avoid fallacies in reasoning? How do we analyse and define concepts? This course provides basic knowledge of conceptual analysis and argumentation theory as well as methods for identifying, reconstructing and evaluating claims and arguments. Its focus is on systematically addressing the following two questions: What do you mean? How do you know? The first question aims at a better understanding of the claim in question, the second at assessing the reasons that support or undermine the claim. We exercise and improve the abilities to address these questions by using texts on scientific and ethical questions concerning the environment and sustainable development. The course provides thus crucial skills for Critical Thinking, which aims at responsible argumentation, communication and action.

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are presented from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples.

The course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

The reader and additional lecture material and exercises will be posted on Moodle.

The detailed semester program (syllabus) is made available to the students at the beginning of the semester.

The reader and additional lecture material on moodle.

Not for students belonging to D-MTEC!

This is a compulsory course in the social sciences and humanities in the second year of the BA Environmental sciences. For 2 ECTS-credits, all written tasks that are distributed during the course need to be solved.

This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

After successful completion of the course you will be able to:

- Evaluate economic measures.
- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is “perfect competition” and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

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Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

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Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

**Objective**

- to describe the tasks and competencies of environmental scientists compared to those of lawyers.
- to explain in which cases the basic principles and the particular instruments of environmental law apply.
- to identify the shortcomings of environmental law and the legislative needs in this regard.
- to distinguish between the tasks of environmental management and environmental management systems.

**Abstract**

Environmental law regulates the protection of human beings and their environment, such as animals, plants, habitats, soil, waters and air. It plays an increasing role in relation to public and private projects. The lecture gives an overall view of Swiss environmental law. Specific subjects will be dealt with in more detail based on case studies and group work.

**Course Syllabus**

- Environmental Law
- Environmental Management

**Delivery of a case study, worked out in groups. Language: Teaching in English on request.**

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**Elections**

**Module Economics**

**Number** | **Title** | **Type** | **ECTS** | **Hours** | **Lecturers**
--- | --- | --- | --- | --- | ---
151-0757-00L | Environmental Management | W | 2 credits | 2G | R. Zust

**Abstract**

An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

**Objective**

- Overview on environmental management and environmental management systems, general methods and principles.

**Content**

Introduction to environmental management / environmental management systems, energy and material flows; economical and ecological problems in industry; characterisation of an enterprise (incl. management handbook); structure and contents of an environmental management system; overview on the ISO 14001 ff. series; methods for environmental evaluation and assessment; integrated management systems; planning methodology and life-cycle-design design; planning example

**Lecture notes**

Information about environmental management and environmental management systems will be provided by a CD or mail.

**Literature**

a list with literatures and links will be provided

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351-0778-00L | Discovering Management | W | 3 credits | 3G | B. Clarysse, S. Brusoni, F. Da Conceição Barata, H. Franke, V. Hoffmann, P. Tinguely, L. P. T. Vandeweghe

**Abstract**

Discovering Management offers an introduction to the field of business management and entrepreneurship for engineers and natural scientists. By taking this course, students will enhance their understanding of management principles and the tasks that entrepreneurs and managers deal with. The course consists of theory and practice sessions, presented by a set of area specialists at D-MTEC.

The general objective of Discovering Management is to introduce students into the field of business management and entrepreneurship.

**Objective**

- The course will help students to successfully take on managerial and entrepreneurial responsibilities in their careers and / or appreciate the challenges that entrepreneurs and managers deal with.

**Content**

- The course consists of a set of theory and practice sessions, which will be taught on a weekly basis. The course will cover business management knowledge in corporate as well as entrepreneurial contexts.
- The course consists of three blocks of theory and practice sessions: Discovering Strategic Management, Discovering Innovation Management, and Discovering HR and Operations Management. Each block consists of two or three theory sessions, followed by one practice session where you will apply the theory to a case.
- The theory sessions will follow a "lecture-style" approach and be presented by an area specialist within D-MTEC. Practical examples and case studies will bring the theoretical content to life. The practice sessions will introduce you to some real-life examples of managerial or entrepreneurial challenges. During the practice sessions, we will discuss these challenges in depth and guide your thinking through team coaching.
- Through small group work, you will develop analyses of each of the cases. Each group will also submit a "pitch" with a clear recommendation for one of the selected cases. The theory sessions will be assessed via a multiple choice exam.

**Lecture notes**

All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

These course materials will form the point of departure for the lectures, class discussions and team work.
351-0778-01L  
**Discovering Management (Exercises)**

**Objective:**
The general objective of Discovering Management (Exercises) is to complement the course "Discovering Management" with one larger additional exercise.

**Content:**
Students who are enrolled for "Discovering Management Exercises" are asked to write an essay about a particular management issue of choice, using your insights from Discovering Management.

**Literature:**
All course materials (readings, slides, videos, and worksheets) will be made available to inscribed course participants through Moodle.

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>assessed</td>
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</tbody>
</table>

**363-0387-00L  
**Corporate Sustainability**

**Objective:**
- assess the limits and the potential of corporate sustainability for sustainable development
- develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method.
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams with different output formats (tv-style debate, consultancy pitch, technology model walk-through, campaign video)

**Content:**
In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share their insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

**Lecture notes:**
http://www.sustec.ethz.ch/teaching/lectures/corporate-sustainability.html

**Prerequisites / notice:**
TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

**363-0537-00L  
**Resource and Environmental Economics**

**Abstract:**
A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.
Content
The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit-analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature

351-1109-00L Introduction to Microeconomics
GESS (Science in Perspective):
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

Abstract
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

Objective
Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

Content
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

Lecture notes
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

Literature

Prerequisites / notice
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.

Fostered competencies
Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
decision-making assessed
Media and Digital Technologies not assessed
Problem-solving not assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork not assessed
Customer Orientation not assessed
Leadership and Responsibility not assessed
Self-presentation and Social Influence not assessed
Sensitivity to Diversity not assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility not assessed
Creative Thinking not assessed
Critical Thinking assessed

351-1109-00L
Introduction to Microeconomics

W 3 credits 2G M. Wörter, M. Beck


This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics and emerge, and evolve, and the conditions under which such efforts and the respective public policies are effective. 

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics and emerge, and evolve, and the conditions under which such efforts and the respective public policies are effective.

When you finish this course, you will be able to:

- Understand the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.


Leistungskontrollen
a) Erster Test (...)

b) Zweiter Test (...)

Ergeben gemittelt das Ergebnis der benoteten Semesterleistung

Kreditpunkte
4 ECTS-Punkte (Zeitaufwand insgesamt ca. 120 Arbeitsstunden)

Lecture notes


Leistungskontrollen
a) Erster Test (...)
b) Zweiter Test (...)

Ergeben gemittelt das Ergebnis der benoteten Semesterleistung

Kreditpunkte
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Lecture notes


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Lecture notes


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Kreditpunkte
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Lecture notes


Leistungskontrollen
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b) Zweiter Test (...)

Ergeben gemittelt das Ergebnis der benoteten Semesterleistung

Kreditpunkte
4 ECTS-Punkte (Zeitaufwand insgesamt ca. 120 Arbeitsstunden)
Module Individual Sciences

<table>
<thead>
<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-0721-00L</td>
<td>Psychology</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>R. Hansmann, A. Bearth, M. Siegrist</td>
</tr>
</tbody>
</table>
| Abstract     | This course provides an introduction to psychological research and modeling, focusing on cognitive psychology and the psychological experiment. Participants learn to formulate problems for psychological investigation and apply basic forms of psychological experiment. Students are able to:
- describe the areas, concepts, theories, methods, and findings of psychology.
- differentiate scientific psychology from "everyday" psychology.
- structure the conclusions and significance of an experiment according to a theory of psychology.
- formulate a problem for psychological investigation.
- apply basic forms of psychological experiment. |
| Objective    | Einführung in die psychologische Forschung und Modellbildung unter besonderer Berücksichtigung der kognitiven Psychologie und des psychologischen Experiments. Themen sind u.a.: Wahrnehmung; Lernen und Entwicklung; Denken und Problemlösen; Kognitive Sozialpsychologie; Risiko und Entscheidung. |
| Content      | This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person. |

| 752-2120-00L | Consumer Behaviour I                       | W    | 2    | 2V    | M. Siegrist, A. Bearth, A. Berthold |
| Abstract     | Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior. |
| Objective    | Introduction in consumer research. The following aspects will be emphasized in the course: Consumer decision making, individual determinants of consumer behavior, environmental influences on consumer behavior, influencing consumer behavior. |
| Content      | This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person. |

| 701-0785-00L | Introduction to Science Communication (University of Zurich) | W    | 4    | 2V    | M. Schäfer |
| Abstract     | Does not take place this semester. |
| Objective    | Goals: Learning to understand structures and processes of environmental and science communication, becoming more sensitive for problems of science public relations, getting an insight into public debates about environmental issues. Methods: invitation of media practitioners and experts, discussions, lectures on key theoretical concepts of communication. Topics: Concrete communication instruments like media conferences, theoretical perspectives of public relations, basic principles and examples of information campaigns, environment and science as media topics, functions and structures of science communication, relations between science, media, and politics. |
| Content      | I. Introduction
- Topics: Environment, Science, Risks, Media
- Forms, Functions, Effects of Public and Mass Communication

II. Stakeholders and their Public Relations Efforts
- Public Relations and Science PR: Theoretical Perspectives, Instruments

III. Science and Environmental Issues in the Media
- Forms and Functions of Science Journalism
- Problems of Selection, Interpretation, Quality
- Media Content Analysis
- Online Communication

IV. Uses and Effects of Science and Environmental Communication
- Extent of Media Use
- Effects on Knowledge, Risk Perceptions, Environmental Attitudes
- Effects on Science itself |
| Lecture notes| Literature and powerpoint presentations will be provided on the OLAT platform. |

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2205 of 2416
Introduction to general and applied ethics.

Participants should already have reached C1 level (advanced) as defined in the Common European Framework of Reference for ECTS.

Lecturers

Type

University lecturers

Advanced English for Academic Purposes (C1-C2)

This course is designed for Bachelor's and Master's students from all disciplines who wish to improve their English from C1 towards C2 level and train their language skills at mastery level. Selected academic English features are included to add value to the course to meet standard entrance requirements by leading universities and colleges worldwide.

The course aims to train and develop linguistic skills at mastery level, with a focus on formal and informal academic lexis, on listening and oral communication skills, and on increasing fluency, accuracy, and complexity of spoken language. Students will work on writing well-structured descriptive texts and argumentative essays, with the aim of fulfilling the language requirements for study at an English-speaking university or following university Master’s courses held in English.

Highly recommended Natural Science and Technical Electives

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2206 of 2416
For the Specialization in Biogeochemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0225-00L</td>
<td>Organic Chemistry</td>
<td>W</td>
<td>2 credits</td>
<td>2V+1U</td>
<td>K. McNeill</td>
</tr>
</tbody>
</table>

Abstract

Objective
This course builds on General Chemistry I and II. The students will learn the basic reaction mechanisms in organic chemistry. They will be able to understand and formulate simple organic reactions.

Content
Descriptive chemistry of functional groups (alkyl halides, alkenes, aromatic systems, carbonyls). Reaction mechanisms (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution). NMR spectroscopy.

Literature
Carsten Schmuck, Basisbuch Organische Chemie, Pearson

Prerequisites / notice
Der Stoff der Basischemie wird vorausgesetzt.

For the Specialization in Human-Environment Systems

<table>
<thead>
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<th>Number</th>
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</tr>
</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
</tr>
</tbody>
</table>

Abstract
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Objective
Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.

Content
Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.

Literature

Prerequisites / notice
The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

401-0649-00L | Applied Statistical Regression               | W    | 5 credits | 2V+1U  | M. Dettling |

Data: 01.11.2022 12:41
Lecture notes and handouts

- The Human Body: nomenclature, orientations, tissues

**Abstract**

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

Lecture notes

A script will be available.

**Literature**

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

**Prerequisites / notice**

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.

**Fostered competencies**

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

For the Specialization in Environmental Biology

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>227-0399-10L</td>
<td>Physiology and Anatomy for Biomedical Engineers I</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Wyss</td>
</tr>
</tbody>
</table>

**Abstract**

Students will be able to identify and enumerate important anatomical structures to describe basic physiological processes of the human body to use a 3d animation database/software to use 'anatomical language' to retrieve anatomical structures to understand basic medical terminology

**Objective**

To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.

**Content**

- The Human Body; nomenclature, orientations, tissues
- Musculoskeletal system, Muscle contraction
- Blood vessels, Heart, Circulation
- Blood, Immune system
- Respiratory system
- Acid-Base-Homeostasis

**For the Specialization in Forest and Landscape**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0266-00L</td>
<td>Introduction to Dendrology</td>
<td>W</td>
<td>3 credits</td>
<td>3P</td>
<td>A. Rudow</td>
</tr>
</tbody>
</table>

**Abstract**

Woody plants are important elements of forest ecosystems and landscapes. The course gives an introduction to dendrology as well as to the identification of native tree and shrub species. It is a highly recomended course for the BSc specialization of Forest and Landscape and it provides the basic requirements for the consecutive course Woody Plants of Central Europe in the spring semester.

**Objective**

Knowledge of selected native tree and shrub species. Understanding of biological and ecological relations by means of in situ observation of woody plants. Differentiated view on forest ecosystems.

**Content**

Introduction to dendrology on the basis of concrete examples. Emphasis on identification of tree and shrub species (80 frequent tree and shrub species) and on the understanding of tree structure (morphology of woody plants). The illustrating way of presentation and the relations between different scale levels (organ, individual, stand, ecosystem) provide an attractive insight into forest and landscape topics as well as into environmental biology.
Theoretical basics and fundamental concepts of Geographic Information Science (GIS) are imparted and subsequently further elaborated with the software ArcGIS. At the end, the students will be able to independently solve basic realistic GIS problems.

Content
The course covers the following topics:
- What is GIS? What are spatial data?
- The representation of reality by means of spatial data models: vector, raster, TIN
- The four phases of data modelling: Spatial, conceptual, logical and physical model
- Possibilities of data collection
- Transition of reference frame
- Spatial Analysis I: query and manipulation of vector data
- Spatial Analysis II: operators and functions with raster data
- Digital elevation models and derived products
- Process modelling with vector and raster data
- Presentation possibilities of spatial data

Abstract
The course shall particularly elucidate the cross section of Agro- and Food Sciences in the context of important global problems to be solved. Furthermore the students in the first year of studies shall be given some insight and outlook supporting the development of their views and interests in agricultural and food sciences further.

The course is part of the block exam after the first study year. Paper copies can be used ("Open Book") during the on-line exam, but no other means are not allowed. The course is mainly taught in German, single might be in English.

The course provides the basic knowledge for the advanced course 701-0316-00L Woody plants of Central Europe (Dendrology 2).
The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO₂ concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO₂ gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data is included.

Objective
The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Content
The course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems. This course covers current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.
Objective

1. Systematically analyse and discuss case studies from ongoing agroecological and food system research.
2. Learn and experiment on methods for field and laboratory investigations in agroecology.
3. Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
4. Reflect critically on agricultural and food system transformation tools and methods from the perspective of a food system stakeholder.
5. Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content

The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) in both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management).

The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholder in the food system in order to support a sustainable transformation.

Agroecology (HS)

In Spring Semester a related course (Agroecology FS) will be offered. The course Agroecology (HS) is not a prerequisite, the courses can be taken independent of each other.

Abstract

Agroecology is a discipline, an agricultural practice, and a political-social movement. Students will attend five public lectures in which experts from different fields reflect on agroecology and its principles. Based on these inputs, students will reflect and discuss about the role of agroecology to support sustainable agriculture and food systems.

Objective

Students know the thirteen principles of the High-Level Panel of Experts (HLPE) of the Committee on World Food Security as well as the ten elements of agroecology suggested by FAO and can critically reflect on the important properties as well as benefits and trade-offs of agroecological systems and approaches.

Students will be able to transfer their disciplinary and interdisciplinary knowledge about the thirteen principles as guiding principles for policymakers, practitioners, and other stakeholders across the food system in planning, managing, and evaluating agroecological transformation. Students are part of groups focusing on one of 13 principles of the HLPE. During the course, students discuss the potential and limitations of agroecology and learn about scientific contributions to agroecology. Students form an opinion on the role of agroecology as well as to reflect and argue on the different facets and develop recommendations for real-world applications of agroecology in supporting a transition towards sustainable food systems.

Content

The course is designed as a combination of a series of five public lectures/webinars on “Agroecology and the Transformation to Sustainable Food Systems” delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended to fuel the students’ sessions in the second part of each course. In the student sessions the student groups first get to know one of the 13 principles of agroecology proposed by the High-Level Panel of Experts (HLPE) of the Committee on World Food Security. They identify “unknows” and link to other closely related principles. The groups then work out the perspective of a chosen stakeholder. Finally, the groups will take part in a scientific discussion representing their stakeholder perspective. All groups will synthesize their discussions in a short report.

Lecture notes

Handouts will be available on the webpage of the course.

Literature


Report of HLPE on agroecology:

Prerequisites / notice

This course is based on fundamental knowledge about plant ecophysiology, soil science, biogeochemistry, crop and forage science, and ecology in general. The course will be taught in English. The course is offered in spring and fall (different agroecology principles will be addressed). Thus, both courses are not sequential, but can be taken in any order.

Fostered competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies

Social Competencies
Cooperation and Teamwork

Personal Competencies
Critical Thinking

Agroecology (FS)

The course is designed as a combination of a series of five public lectures/webinars on “Agroecology and the Transformation to Sustainable Food Systems” delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended to fuel the students’ sessions in the second part of each course. In the student sessions the student groups first get to know one of the 13 principles of agroecology proposed by the High-Level Panel of Experts (HLPE) of the Committee on World Food Security. They identify “unknows” and link to other closely related principles. The groups then work out the perspective of a chosen stakeholder. Finally, the groups will take part in a scientific discussion representing their stakeholder perspective. All groups will synthesize their discussions in a short report.

Abstract

The overall goal of this course is to provide general knowledge about the behaviour, housing and welfare of domestic animals. Students will:

- Understand the basis of animal behaviour and how it is measured
- Acquire knowledge of housing systems and management of domestic animals
- Get a concept of animal needs and welfare

Literature


Prerequisites / notice

Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Scored competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies

Social Competencies
Cooperation and Teamwork

Personal Competencies
Critical Thinking

751-5005-00L Animal Housing and Behaviour

W 1 credit 1V S. Goumon

Objective

The course is designed as a combination of a series of five public lectures/webinars on “Agroecology and the Transformation to Sustainable Food Systems” delivered by national and international experts and scientists as well as sessions in which students reflect on the topics addressed in the lecture series in a group work format. The public lectures bring different perspectives to the discussion and are intended to fuel the students’ sessions in the second part of each course. In the student sessions the student groups first get to know one of the 13 principles of agroecology proposed by the High-Level Panel of Experts (HLPE) of the Committee on World Food Security. They identify “unknows” and link to other closely related principles. The groups then work out the perspective of a chosen stakeholder. Finally, the groups will take part in a scientific discussion representing their stakeholder perspective. All groups will synthesize their discussions in a short report.

Abstract

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- Get a concept of animal needs and welfare

Literature


Prerequisites / notice

Prior participation in the lecture Nachhaltige Agrarökosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.
### Biomedicine

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<td>W</td>
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<tr>
<td><strong>Abstract</strong></td>
<td>Students will be able to identify and enumerate important anatomical structures&lt;br&gt;to describe basic physiological processes of the human body&lt;br&gt;to use a 3D animation database/software&lt;br&gt;to retrieve anatomical structures&lt;br&gt;to understand basic medical terminology</td>
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<td><strong>Objective</strong></td>
<td>To understand basic principles and structure of the human body in consideration of the clinical relevance and the medical terminology used in medical work and research.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>- The Human Body: nomenclature, orientations, tissues&lt;br&gt;- Musculoskeletal system, Muscle contraction&lt;br&gt;- Blood vessels, Heart, Circulation&lt;br&gt;- Blood, Immune system&lt;br&gt;- Respiratory system&lt;br&gt;- Acid-Base-Homeostasis</td>
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<td><strong>Lecture notes</strong></td>
<td>Lecture notes and handouts</td>
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| 551-0317-00L | Immunology I | W    | 3 credits | 2V    | M. Kopf, A. Oxenius |
| **Abstract** | Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response. |      |      |       |                    |
| **Objective** | Introduction into structural and functional aspects of the immune system. Basic knowledge of the mechanisms and the regulation of an immune response. |      |      |       |                    |
| **Content** | - Introduction and historical background<br>- Innate and adaptive immunity, Cells and organs of the immune system<br>- B cells and antibodies<br>- Generation of diversity<br>- Antigen presentation and Major Histoincompatibility (MHC) antigens<br>- Thymus and T cell selection<br>- Autoimmunity<br>- Cytotoxic T cells and NK cells<br>- Th1 and Th2 cells, regulatory T cells<br>- Allergies<br>- Hypersensitivities<br>- Vaccines, immune-therapeutic interventions |      |      |       |                    |

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2212 of 2416
To introduce the students to the both macro- and micronutrients in relation to food and metabolism.

Soil and Water Chemistry

752-6001-00L

Introduction to Nutritional Science

W  3 credits  2V  M. B. Zimmermann, C. Wolfrum

Abstract

This course introduces basic concepts of micro- and macronutrient nutrition. Micronutrients studied include fat-soluble and water-soluble vitamins, minerals and trace elements. Macronutrients include proteins, fat and carbohydrates. Special attention is given to nutrient digestion, bioavailability, metabolism and excretion with some focus on energy metabolism.

Objective

To introduce the students to the both macro- and micronutrients in relation to food and metabolism.

Content

The course is divided into two parts. The lectures on micronutrients are given by Prof. Zimmermann and the lectures on macronutrients are given by Prof. Wolfrum. Prof. Zimmermann discusses the micronutrients, including fat-soluble vitamins, water-soluble vitamins, minerals and trace elements. Prof. Wolfrum introduces basic nutritional aspects of proteins, fats, carbohydrates and energy metabolism. The nutrients are described in relation to digestion, absorption and metabolism. Special aspects of homeostasis and homeorhesis are emphasized.

Lecture notes

There is no script. Powerpoint presentations will be made available.

Literature

Elmadfa I & Leitzmann C: Ernährung des Menschen
UTB Ulmer, Stuttgart, 4. überarb. Ausgabe 2004

Garrow JS and James WPT: Human Nutrition and Dietetics
Churchill Livingstone, Edinburgh, 11th rev. ed. 2005

Soil Sciences

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>701-0533-00L</td>
<td>Soil and Water Chemistry</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. Kretschmar, D. I. Christl, L. Winkel</td>
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</tbody>
</table>

Abstract

This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.

Objective

1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants.
2. Quantitative applications of chemical equilibria to processes in natural systems.

Content

Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

Lecture notes

Lecture slides on Moodle

Literature

–Chapters 1, 3, 4, 6, 7 and 11 in Sigg/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016.

Prerequisites / notice

The lecture courses Pedosphere and Hydrosphere are highly recommended.

Environmental Soil Physics/Vadose Zone Hydrology

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0535-00L</td>
<td>Environmental Soil Physics/Vadose Zone Hydrology</td>
<td>W</td>
<td>3</td>
<td>2V+1U</td>
<td>A. Carminati, P. U. Lehmann Grunder</td>
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</tbody>
</table>

Abstract

The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/ near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.
Students are able to
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils

Week 1 (September 21): Introduction, content, structure of the course, objectives, bibliography, grading and evaluation; soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density.

Week 2 (September 28): Pore scale consideration, pore sizes, shapes and connectivity, coordinate number, continuity and percolation; surface tension; Young-Laplace equation; capillary rise; contact angle.

Week 3 (October 05): Friction and laminar flow; Hagen-Poiseuille's law; Washburn equation; numerical lab (including report)

Week 4 (October 12): Soil water content; soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point.

Week 5 (October 19): Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; Demo lab (including report)

Week 6 (October 26): Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy's Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman); effective conductivity; unsaturated hydraulic conductivity; Buckingham law.

Week 7 (November 02): Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8 (November 09): Numerical solution of Richards equation – Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)

Week 9 (November 16): Solute and gas transport in soils - Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 10 (November 23): Conductivity and resistance of soils – differences and similarities of hydraulic, electrical, thermal conductivities; Buckingham-Darcy, Fourier, and Archie's law; pore scale characteristics and effective conductivities; soil thermal properties; steady state and non-steady heat flow

Week 11 (November 30): Energy balance and land atmosphere interactions - Radiation and energy balance; evapotranspiration, potential and actual evaporation, definitions and estimation; evaporation stages and characteristic length

Week 12 (December 07): Root water uptake and transpiration – Mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance

Week 13 (December 14): Summary, questions, old exam

Week 14 (December 21): Written Semester-end exam

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

Geology and Petrography


Übungen zum Gesteinsbestimmen und Lesen von geologischen, tektonischen und geotechnischen Karten, einfache Konstruktionen.

Weekly handouts of PPT slides via MyStudies

Geology and Petrography

This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts. The course consists of weekly lectures and bi-weekly exercises in groups.

Objective


Literature

The course is based on Press & Siever book Dynamic Earth by Grotzinger et al., available to ETH students via https://link.springer.com/book/10.1007/978-3-662-48342-8

Introduction to Engineering Geology

This introductory course starts from a descriptions of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

Objective

Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

Content


Weekly lecture slides available on moodle.

Plant Nutrition I

This course gives an overview of the basic concepts of geology and petrography and shows some links to the application of these concepts.

Objective

Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

Content


Written course documentation available on moodle.

Geological mass wasting processes.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2214 of 2416
The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear models. A general introduction explains the needs of appropriately managing nutrients in plant production. Afterwards, we will study the physiology of plant nutrition (nutrient uptake by roots; nutrient transports in the plant; physiological roles of nutrients in the plant). Then the role of nutrients for yield formation and their effects on crop quality is dealt with. Finally, the bases of crop fertilization are taught (availability of nutrient in soil; N, P and K fertilization; different types of fertilizers).

**Literature**


Schubert S 2006 Pflanzenernährung Grundwissen Bachelor Uner UTB


**Prerequisites / notice**

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software R, for which an introduction will be held.

## Methods of Statistical Data Analysis

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>L. Meier</td>
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<tr>
<td></td>
<td>Abstract</td>
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<tr>
<td></td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<td>Objective</td>
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<td>Participants will be able to plan and analyze efficient experiments in the fields of natural sciences. They will gain practical experience by using the software R.</td>
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<td>Content</td>
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<td></td>
<td>Principles of experimental design, one-way analysis of variance, contrasts and multiple comparisons, multi-factor designs and analysis of variance, complete block designs, Latin square designs, random effects and mixed effects models, split-plot designs, incomplete block designs, two-series factorials and fractional designs, power.</td>
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<td>Literature</td>
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<td>Prerequisites / notice</td>
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<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression</td>
<td>W</td>
<td>5 credits</td>
<td>2V+1U</td>
<td>M. Dettling</td>
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<tr>
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<td>Abstract</td>
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<td>This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning “good practice” that can be applied in every student’s own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.</td>
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<td>Objective</td>
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<td></td>
<td>The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.</td>
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<td>Content</td>
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<td>The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies. The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.</td>
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<td>Lecture notes</td>
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<td>A script will be available.</td>
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<tr>
<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>Faraway (2005): Linear Models with R</td>
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<td></td>
<td>Faraway (2006): Extending the Linear Model with R</td>
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<td>Draper &amp; Smith (1998): Applied Regression Analysis</td>
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<td>Fox (2008): Applied Regression Analysis and GLMs</td>
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<td></td>
<td>Montgomery et al. (2006): Introduction to Linear Regression Analysis</td>
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<td>Prerequisites / notice</td>
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<td>The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held. In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L “Applied Statistical Regression” and 401-3622-00L “Statistical Modelling” are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.</td>
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### 401-6215-00L Using R for Data Analysis and Graphics (Part I)

**W 1.5 credits 1G M. Mächler**

**Abstract**
The course provides the first part an introduction to the statistical/graphical/data science software R (https://www.r-project.org/) for scientists. Topics covered are data generation and selection, graphical and basic statistical functions, creating simple functions, basic types of objects.

**Objective**
The course provides the first part of an introduction to the statistical software R for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part I of the course covers the following topics:
- What is R?
- R Basics: reading and writing data from/to files, creating vectors & matrices, selecting elements of dataframes, vectors and matrices, arithmetics;
- Types of data: numeric, character, logical and categorical data, missing values;
- Simple (statistical) functions: summary, mean, var, etc., simple statistical tests;
- Writing simple functions;
- Introduction to graphics: scatter-, boxplots and other high-level plotting functions, embellishing plots by title, axis labels, etc., adding elements (lines, points) to existing plots.

The course focuses on practical work at the computer with R. We will make use of the graphical user interface RStudio: www.rstudio.org

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving, Project Management
- Personal Competencies: Adaptability and Flexibility, Creative Thinking, Critical Thinking, Integrity and Work Ethics, Self-awareness and Self-reflection, Self-direction and Self-management

**Lecture notes**
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf

**Prerequisites / notice**
The course resources will be provided via the Moodle web learning platform. Subscribing via Mystudies "automatically" makes you a student participant of the Moodle course of this lecture, which is at https://moodle-app2.let.ethz.ch/course/view.php?id=18279

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### 401-6217-00L Using R for Data Analysis and Graphics (Part II)

**W 1.5 credits 1G M. Mächler**

**Abstract**
The course provides the second part an introduction to the statistical software R for scientists. Topics are data generation and selection, graphical and basic statistical functions, types of objects, models, programming and writing functions. Note: This part builds on "UsingR... (Part I)", but can be taken independently if the basics of R are already known.

**Objective**
The course provides the second part of an introduction to the statistical software R (https://www.r-project.org/) for scientists. R is free software that contains a huge collection of functions with focus on statistics and graphics. If one wants to use R one has to learn the programming language R - on very rudimentary level. The course aims to facilitate this by providing a basic introduction to R.

Part II of the course covers the following topics:
- Elements of the R language: control structures (if, else, loops), lists, overview of R objects, attributes of R objects;
- More on R functions;
- Applying functions to elements of vectors, matrices and lists;
- Object oriented programming with R: classes and methods;
- Tayloring R: options;
- Extending basic R: packages

The course focuses on practical work at the computer. We will make use of the graphical user interface RStudio: www.rstudio.org

**Fostered competencies**
- Subject-specific Competencies: Concepts and Theories, Techniques and Technologies, Analytical Competencies, Decision-making, Media and Digital Technologies, Problem-solving
- Social Competencies: Communication, Cooperation and Teamwork
- Personal Competencies: Adaptability and Flexibility, Creative Thinking

**Lecture notes**
An Introduction to R. http://stat.ethz.ch/CRAN/doc/contrib/Lam-IntroductionToR_LHL.pdf
The course covers the ecology and conservation biology of birds and mammals. Important concepts from physiology, behavioural ecology, population biology, biogeography and community ecology will be linked to applications in conservation and management. A worldwide perspective will be complemented by a focus on the Central European fauna and its dynamics. The students are familiar with important topics in animal ecology of vertebrates, with an emphasis on birds and mammals. They are able to link theoretical concepts with ecological phenomena and view them against an evolutionary backdrop. They can thus appraise applied aspects of the conservation and the use of animal populations, such as the influence of food availability on habitat use of birds and mammals, relationships between predators and prey species, or of herbivores on vegetation, and the effects of hunting and landscape change on animal populations. Students understand the biogeographical characteristics of the Central European vertebrate fauna and its temporal and spatial dynamics.

The course deals with a number of main topics that include feeding and resource use, spatial behaviour and migrations, reproduction, population dynamics, competition and predation, parasites and diseases, biodiversity and distributions, and dynamics of the Central European fauna. There is an emphasis on linking theory with management issues in conservation and management of wildlife populations. During the first half of the course, examples will be drawn worldwide whereas during the second half, the course will focus more strongly on the European fauna, particularly of the Alpine region. Although the course is not designed to teach natural history of the native species, examples will cover much of the taxonomic breadth of the European fauna. The course includes a field excursion.

Program (KB: Kurt Bollmann, N/A: 2nd lecturer):
26.9.22 Birds and mammals: similarities & differences, endothermy & body isolation, moult in birds (KB+N/A)
03.10.22 Feeding I: Food, metabolism (KB)
10.10.22 Feeding II: Energetic needs, foraging, digestion (KB)
17.10.22 Distribution and habitat use, bird migration (self-study)
24.10.22 Reproduction, litter and clutch size, breeding systems (N/A)
31.10.22 Population dynamics (KB)
07.11.22 Predator, predator-prey-cycles (KB)
14.11.22 Competition (N/A), Parasitism and diseases (self-study)
21.11.22 Biogeography of central European birds and mammals (KB)
28.11.22 Herbivores as landscape engineers (self-study)
05.12.22 Threats to birds and mammals, incl. climate change (KB)
12.12.22 Conservation biology of selected species (N/A)
19.12.22 Exploitation of mammals and birds + pilot test (KB)

Lecture notes
Lecture notes will be available for CHF 15.

Literature
Some books relevant to the course are (optional reading):
- Suter, W. 2017. Ökologie der Wirbeltiere. Vögel und Säugetiere. UTB/Haupt, Bern. This book is based on the course. It is in German.

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: not assessed

- Method-specific Competencies
  - Analytical Competencies: not assessed
  - Decision-making: not assessed
  - Media and Digital Technologies: not assessed
  - Problem-solving: not assessed
  - Project Management: not assessed

- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed

- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: not assessed
  - Self-direction and Self-management: not assessed

701-0405-00L Fresh Water: Concepts and Methods for Sustainable Management

Abstract
In this course, we will discuss inland water ecosystems, their basic ecological characteristics, as well as their anthropogenic influences and changes. Case studies are used to discuss concepts and methods for sustainable management. The case studies are mostly from Switzerland and refer to the Water Protection Act and the Swiss Biodiversity Strategy.

Objective
- basics concerning the functioning of the most important freshwater ecosystems
- basics of the sustainable management of aquatic ecosystems
- application of these principles with case studies
- critical analyses, organization of discussion groups

https://moodle-app2.let.ethz.ch/course/view.php?id=15522
Contents

1) 1st lesson: Student working groups, working method

2) Biodiversity in floodplains
3) Revitalization of rivers and lakes
4) Floodplain management and revitalization
5) Protection of watercourses and lakes
6) River widenings and ramps
7) Restoration of the sediment dynamics
8) Changing discharge and temperature regimes in rivers and lakes
9) Planning and operation of pumped storage power plants
10) Water and health, including climate change
11) Fish migration in multi-purpose watercourses
12) Mire protection
13) Final/ Evaluation/ Feedback

Lecture notes

Themenspezifische Unterlagen (Vorlesung Dozierende, Literatur) werden verteilt und auf Moodle zugänglich gemacht (Link folgt).

Literature

Literaturlisten zu den Gruppenarbeiten werden abgegeben und auf Moodle zugänglich gemacht (Link folgt).

Prerequisites / notice

Students will organize discussion groups.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed

Project Management assessed

Social Competencies
Communication assessed

Cooperation and Teamwork assessed
Customer Orientation assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed

Personal Competencies
Negotiation assessed

Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed

Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

551-0421-00L Biology and Ecology of Fungi in Forests

Number of participants limited to 10.

The enrolment is done by the D-BIOL study administration.

Abstract

Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

Objective

Knowledge of the fungi of forest and its ecological significance. Knowing of current methodological research approaches. Self-reliant and deepened activities of selected topics of fungi from forests.

Content

Introduction of the biological and ecological basics of fungi in forests. Focusing on mycorrhizal, saprobic, and pathogenic fungi and their functional relevance in the forest ecosystems. To get to know current methodological research approaches on the basis of selected examples with practical works in forest and lab as well as excursions and lectures.

Lecture notes

Unterlagen zum Kurs werden abgegeben.

Literature


Prerequisites / notice

Der Blockkurs findet an der Eidg. Forschungsanstalt WSL in Birmensdorf statt. Der Wald vor der Haustüre des Institutes macht diesen Kurs besonders praxisnah.

Erreichbarkeit mit Tram 14 bis Triemli, danach PTT-Bus 220 oder 350 bis Birmensdorf Sternen/WSL, oder mit S9 bis Birmensdorf SBB und mit PTT-Bus eine Station in Richtung Zürich bis Birmensdorf Sternen/WSL.

751-3700-00L Plant Ecophysiology

Number of participants limited to 10.

The enrolment is done by the D-BIOL study administration.

Abstract

The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO2 concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO2 gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data is included.

Objective

The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Content

The general theme of this course is the effect of environmental factors (such as light, temperature, relative humidity, CO2 concentrations, etc.) on plant physiology: water uptake and transport, transpiration, CO2 gas exchange of plants (photosynthesis, respiration), growth and C allocation, yield and production, stress physiology. Working with measurement data is included.

Objective

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Content

The students will understand the impact of environmental factors on plant physiology and will learn the theoretical basis and terminology of plant ecophysiology that is necessary to analyze yield potentials in agriculture. The students will learn about classical and latest studies in plant ecophysiology. Students will check and implement their knowledge and understanding of ecophysiology using measurement data.

Lecture notes

Handouts stehen online.

Literature


Prerequisites / notice

This course is based on basics of plant identification and plant physiology. It is the basis for the courses Plant Production, Part Forage Production and Grassland Systems.
This course builds on General Chemistry I and II.

Schwarzenbach, R.P., P.M. Gschwend, and D.M. Imboden.

H. Wernli

Concepts and Theories

Introduction into the most important spectroscopical methods and their applications to gain structural information.

Basics of Organic Chemistry.

This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.

Environmental Fluid Dynamics

This course covers the basic physical concepts and mathematical equations used to describe environmental fluid systems on the rotating Earth. Fundamental concepts (e.g. vorticity dynamics and waves) are formally introduced, applied quantitatively and illustrated using examples. Exercises help to deepen knowledge of the material.

Environmental Physics

Introduction to Environment Organic Chemistry

This course is an introduction to the environmental chemistry of organic molecules, focusing on equilibrium partitioning processes and non-redox reactions.

The students are able to

- name and recognize the most important classes of environmentally relevant anthropogenic chemicals and identify chemical moieties governing their fate processes.
- explain, on the basis of physical-chemical foundations, the most important processes (i.e., partitioning and substitution and elimination reactions) which determine the environmental behavior of organic pollutants.
- identify, on the basis of chemical structure, the processes relevant for the environmental behavior of a compound.
- critically evaluate published work and data.

Overview of the most important classes of environmental pollutants

- Molecular interactions that determine the partitioning behavior (adsorption and absorption processes) of organic compounds between different environmental compartments (gas, liquid, solid)
- Physical-chemical properties (vapor pressure, aqueous solubility, air-water partition constant, organic solvent-water partition constants, etc) and partitioning behavior of organic compounds between environmentally relevant phases (air, aerosols, soil, water, biota)
- Chemical transformation reactions of organic pollutants in aquatic and in terrestrial environments (hydrolysis, elimination, addition)

Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Basic Principles of Spectroscopy

- Raman spectroscopy.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of NMR spectroscopy).
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- Script will be for the production price

Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Method-specific Competencies

Analytical Competencies

Media and Digital Technologies

Problem-solving

Personal Competencies

Critical Thinking

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
701-0201-00L | Introduction to Environmental Organic Chemistry | W | 3 | 2G | M. Sander, K. McNeill

Abstract

This course is an introduction to the environmental chemistry of organic molecules, focusing on equilibrium partitioning processes and non-redox reactions.

Objective

The students are able to

- name and recognize the most important classes of environmentally relevant anthropogenic chemicals and identify chemical moieties governing their fate processes.
- explain, on the basis of physical-chemical foundations, the most important processes (i.e., partitioning and substitution and elimination reactions) which determine the environmental behavior of organic pollutants.
- identify, on the basis of chemical structure, the processes relevant for the environmental behavior of a compound.
- critically evaluate published work and data.

Content

- Overview of the most important classes of environmental pollutants
- Molecular interactions that determine the partitioning behavior (adsorption and absorption processes) of organic compounds between different environmental compartments (gas, liquid, solid)
- Physical-chemical properties (vapor pressure, aqueous solubility, air-water partition constant, organic solvent-water partition constants, etc) and partitioning behavior of organic compounds between environmentally relevant phases (air, aerosols, soil, water, biota)
- Chemical transformation reactions of organic pollutants in aquatic and in terrestrial environments (hydrolysis, elimination, addition)

ECTS

W

3 credits

2G

701-0225-00L | Organic Chemistry | W | 2 | 2V+1U | K. McNeill

Abstract

Basics of Organic Chemistry.

Reaction mechanisms in organic chemistry (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution and NMR spectroscopy)

Objective

This course builds on General Chemistry I and II.

The students will learn the basic reaction mechanisms in organic chemistry. They will be able to understand and formulate simple organic reactions.

Content

Descriptive chemistry of functional groups (alkyl halides, alkynes, aromatic systems, carboxyls).

Reaction mechanisms (substitutions, additions, eliminations, condensations, electrophilic aromatic substitution).

NMR spectroscopy.

Literature

Carsten Schmuck, Basiscbuch Organische Chemie, Pearson

Prerequisites / notice

Die Lehrveranstaltung richtet sich nicht nur an jene Studierenden, welche sich später chemisch vertiefen wollen, sondern ausdrücklich auch an alle jene, welche sich mit der Problematik von organisichen Schadstoffen in der Umwelt vertraut machen wollen, um dieses Wissen in anderen Vertiefungen anzuwenden.

529-0051-00L | Analytical Chemistry I | W | 3 | 3G | D. Günther, M.-O. Ebert, G. Schwarz, R. Zenobi

Abstract

Introduction into the most important spectroscopical methods and their applications to gain structural information.

Objective

Knowledge about the necessary theoretical background of spectroscopical methods and their practical applications

Content

Application oriented basics of organic and inorganic instrumental analysis and of the empirical employment of structure elucidation methods:

- Mass spectrometry: Ionization methods, mass separation, isotope signals, rules of fragmentation, rearrangements.
- NMR spectroscopy: Experimental basics, chemical shift, spin-spin coupling.
- IR spectroscopy: Revisiting topics like harmonic oscillator, normal vibrations, coupled oscillating systems (in accordance to the basics of the related lecture in physical chemistry); sample preparation, acquisition techniques, law of Lambert and Beer, interpretation of IR spectra; Raman spectroscopy.

Lecture notes

Script will be for the production price

Literature

- M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der organischen Chemie, 5. überarbeitete Auflage, Thieme, Stuttgart, 1995

Prerequisites / notice

Exercises are integrated in the lectures. In addition, attendance in the lecture 529-0289-00 "Instrumental analysis of organic compounds" (4th semester) is recommended.
Properties of water, hydrostatics, stability of floating bodies, continuity, Euler equation of motion, Navier-Stokes equations, similarity.

In the course "Hydraulics I", the competency of process understanding is taught, applied and examined. Furthermore, system understanding and measurement methods are taught.


In "Groundwater I" the competencies of process understanding are taught, applied and examined. Furthermore, system understanding and measurement methods are taught.


The course teaches the basics of hydromechanics, relevant for civil and environmental engineers.

Lecture notes: Script and collection of previous problems. Literature: J. Jimenez-Martinez, M. Willmann, 651-3561-00L.

The course provides a quantitative introduction to groundwater flow and contaminant transport.


The course introduces the different components of the cryosphere - snow, glaciers, ice sheets, sea ice and lake ice, and permafrost - and their respective roles in the climate system. For each subsystem, essential physical aspects are emphasized, and their dynamics are described quantitatively and using examples.

Lecture notes: Handouts will be distributed during the teaching semester. Literature: M. Huss, D. Farinotti, H. Zekollari, 651-3561-00L.

The course provides an introduction into the various components of the cryosphere: snow, glaciers, ice sheets, sea ice and lake ice, permafrost, and their roles in the climate system. Essential physical aspects are emphasized for each subsystem: e.g. the material properties of ice, mass balance and dynamics of glaciers, or the energy balance of sea ice.
Further literature will be indicated during the lecture.

<table>
<thead>
<tr>
<th>Fostered competencies</th>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
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Environmental Planning

101-0515-00 Projektmanagement and 103-9313-00 Raum- und Landschaftsentwicklung are prerequisites for the Master's degree programme in Spatial Development and Infrastructure Systems and should be successfully completed in the Bachelor's degree if possible.

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<tr>
<th>Number</th>
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<tr>
<td>701-0009-00L</td>
<td>Tackling Environmental Problems III</td>
<td>W</td>
<td>3 credits</td>
<td>4U</td>
<td>M. Mader, C. E. Pohl</td>
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</tbody>
</table>

Abstract

Students put the measures they developed during the courses Tackling Environmental Problems I & II into practice, in collaboration with partners from civil society, the public and the private sector.

Objective

Students are able to put the measures they developed to address sustainability problems into practice.

Content

In Tackling Environmental Problems I & II, students analyze a sustainability topic, identify a specific problem within it, develop measures to address the problem and test the measures for feasibility by presenting them to concerned stakeholders. Some of the students develop their measures to such a degree, that the measures could actually be implemented. Tackling Environmental Problems III provides the opportunity to do so. Together with partners from civil society, the private and the public sector, students agree on the implementation plan, the financial and legal aspects and put the measure into practice.

Prerequisites / notice

Tackling Environmental Problems I & II is a prerequisite for taking the course Tackling Environmental Problems III.

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<tr>
<td>701-0901-01L</td>
<td>ETH Week 2022: Urban Futures</td>
<td>W</td>
<td>1 credit</td>
<td>3S</td>
<td>F. Rittiner, F. Bargardi, S. Brusoni, R. Knutti, S. Menz, A. Vaterlaus</td>
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</tbody>
</table>

Abstract

ETH Week is an innovative one-week course designed to foster critical thinking and creative learning. Students from all departments as well as professors and external experts will work together in interdisciplinary teams. They will develop interventions that could play a role in solving some of our most pressing global challenges. In 2022, ETH Week will focus on the topic of urban development.

Objective

- Domain-specific knowledge: Students have immersed knowledge about a certain complex, societal topic which will be selected every year. They understand the complex system context of the current topic, by comprehending its scientific, technical, political, social, ecological and economic perspectives.

- Analytical skills: The ETH Week participants are able to structure complex problems systematically using selected methods. They are able to acquire further knowledge and critically analyse the knowledge in interdisciplinary groups and with experts and the help of team tutors.

- Design skills: The students are able to use their knowledge and skills to develop concrete approaches for problem-solving and decision making to a selected problem statement, critically reflect on these approaches, assess their feasibility, to transfer them into a concrete form (physical model, prototypes, strategy paper, etc.) and to present this work in a creative way (role-plays, videos, exhibitions, etc.).

- Self-competence: The students are able to plan their work effectively, efficiently and autonomously. By considering approaches from different disciplines they are able to make a judgment and form a personal opinion. In exchange with non-academic partners from business, politics, administration, non-governmental organizations and media they are able to communicate appropriately, present their results professionally and creatively and convince a critical audience.

- Social competence: The students are able to work in multidisciplinary teams, i.e. they can reflect critically on their own discipline, debate with students from other disciplines and experts in a critical and respectful way and can relate their own positions to different intellectual approaches. They can assess how far they are able to actively make a contribution to society by using their personal and professional talents and skills as "Change Agents".

- Remote collaboration competence: The students work in a hybrid setting blending physical and virtual communication and collaboration methods and tools. They experience the potential and limitations of remote collaboration.
The week is mainly about problem-solving and design thinking applied to the complex world of health and well-being. During ETH Week students will have the opportunity to work in small interdisciplinary groups, allowing them to critically analyse both their own approaches and those of other disciplines, and to integrate these into their work.

While deepening their knowledge about sustainable urban development, students will be introduced to various methods and tools for generating creative ideas and understanding how different people are affected by each part of the system. In addition to lectures and literature, students will acquire knowledge via excursions into the real world, empirical observations, and conversations with researchers and experts.

A key attribute of ETH Week is that students are expected to find their own problems, rather than just solve the problem that has been handed to them.

Therefore, the first three days of the week will concentrate on identifying a problem the individual teams will work on, while the last two days are focused on generating solutions and communicating the team's ideas.

No prerequisites. Programme is open to Bachelor and Masters from all ETH Departments. All students must apply through a competitive application process at www.ethz.ch/ethweek. Participation is subject to successful selection through this competitive process.

The course covers the following topics:
- elucidate the theoretical and conceptional foundations of geographic information systems (GIS)
- identify different tasks of various investor types.
- The students learn basics of renewable energy project realization from acknowledged experts active in the field.
- The students will be able to independently solve basic realistic GIS problems.
- With the software ArcGIS.

One Friday is reserved for a field trip or guest speaker;
- Realization of projects in the field of renewable energies, analysis of legal frame conditions and risks.
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity
- Negotiation
- Adaptable and Flexible
- Creative Thinking
- Critical Thinking
- Self-direction and Self-management

701-0951-00L GIS - Introduction into Geoinformation Science and Technology
Number of participants limited to 75.
Waiting list will be deleted 07.10.2022.

Abstract
Theoretical basics and fundamental concepts of Geographic Information Science (GIS) are imparted and subsequently further elaborated with the software ArcGIS.

Objective
Students are able to
- elucidate the theoretical and conceptional foundations of geographic information systems (GIS)
- independently perform normal GIS work using commercial software and practical examples

Content
The course covers the following topics:
- What is GIS? What are spatial data?
- The representation of reality by means of spatial data models: vector, raster, TIN
- The four phases of data modelling: Spatial, conceptual, logical and physical model
- Possibilities of data collection
- Transition of reference frame
- Spatial Analysis I: query and manipulation of vector data
- Spatial Analysis II: operators and functions with raster data
- Digital elevation models and derived products
- Process modelling with vector and raster data
- Presentation possibilities of spatial data

Literature

701-0967-00L Project Development in Renewable Energies
Number of participants limited to 30.
Waiting list will be deleted 05.10.2022.

Abstract
Realization of projects in the field of renewable energies, analysis of legal frame conditions and risks.

Objective
You will receive a practice-oriented introduction to the regulatory, legal and business requirements for renewable energy projects. The possibilities of integrating fluctuating energy production in an environment of volatile prices will be demonstrated. Exercises based on concrete project examples in groups.

Content
Business models for renewable energy projects
Introduction of market trends, market structure, technical trends and regulation in Switzerland and in the EU internal energy market
Necessary frame conditions for profitable projects
Project development samples and exercises in wind power, hydro power, photovoltaics
due diligence and country assessment.

Exact Program in German below
http://www.rechsteiner-basel.ch/index.php?id=27

Lecture notes
PPT presentation will be distributed (in German)
For group exercise and presentation reasons the number of participants is limited at 30 students.

For exercises students build learning and presentational groups. Credit points are based on group performance.

101-0415-01L  Public Transport and Railways  W  3 credits  2G  A. Nash, H. Orth, S. Schranil

Abstract
Fundamentals of public and collective transport, in its different forms.
Categorization of performance dimensions of public transport systems, and their implications to their design and operations.

Objective
Teaches the basic principles of public transport network and topology design, to understand the main characteristics and differences of public transport networks, based on buses, railways, or other technologies.
Teaches students to recognize the interactions between the infrastructure design and the production processes, and various performance criteria based on various perspective and stakeholders.
At the end of this course, students can critically analyze existing networks of public transport, their design and use; consider and substantiate different choices of technologies to suitable cases; optimize the use of resources in public transport.

Content
Infrastructure: Planning processes and decision levels in network development and infrastructure planning, planning of topologies; tracks and roadways, station infrastructures; Fundamentals of the infrastructure design for lines; track geometries; switches and crossings
Vehicles: Classification, design and suitability for different goals
Network design: design dilemmas, conceptual models for passenger transport on long distance, urban regional transport.
Operations: Passenger/Supply requirements for line operations; timetabling, measures of realized operations, capacity

Lecture notes
Slides, in English, are made available some days before each lecture.

Literature
Reference material books are provided in German and English (list disseminated at lecture), plus Skript Bahninfrastruktur; System- und Netzplanung

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management

Social Competencies
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation

Personal Competencies
Adaptability and Flexibility
Creative Thinking
Critical Thinking
Integrity and Work Ethics
Self-awareness and Self-reflection
Self-direction and Self-management

103-0313-00L  Spatial Planning and Landscape Development  W  5 credits  4G  A. Grêt-Regamey,  Y. M. Räth,  J. Van Wezemael

Autumn Semester 2022
Abstract The lecture introduces into the main-features of spatial planning. Attended will be the subjects planning as a national responsibility, instruments of spatial planning, techniques for problem solving in spatial planning and the Swiss concept for national planning. The lecture is complemented with in-depth topics and international examples.

Objective Die Studierenden kennen die Grundzüge der Raumplanung, ihre wichtigsten Instrumente und Problemlösungsverfahren. Sie können das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Übungsaufgaben umsetzen.

- Grundzüge der Raumplanung und ihre wichtigsten Instrumente kennenlernen
- Erarbeiten der Fähigkeit, räumliche Probleme zu erkennen und Problemlösungsverfahren auf diese anzuwenden
- Planung und Landmanagement als interaktiven Prozess kennenlernen und anwenden
- Verstehen der mit Fläche und Boden verbundenen Potentiale, Nutzungen und Prozesse
- Das vermittelte theoretische Wissen direkt an konkreten, praxisorientierten Fallbeispielen umsetzen können

Content Die Vorlesung deckt die Grundlagen der (Schweizerischen) Raumplanung und Landschaftsentwicklung ab:

- Was ist Raumplanung (Begriffe)
- Prinzipien der Raumplanung
- Die Raumplanung als staatliche Aufgabe - Raumordnungspolitik
- Instrumente der Raumplanung auf den Planungsebenen (u.a. Sachpläne und Konzepte, Richtplanung, Nutzungsplanung, Sondernutzungsplanung, Landumlageverfahren)
- Problemlösungsverfahren in der Raumplanung - systemtechnisches Vorgehen
- Das schweizerische Raumordnungskonzept

Der Schwerpunkt der Vorlesung liegt auf der Erläuterung der Raumplanung als Problemlösungsverfahren. Das dabei vermittelte theoretische Wissen wird direkt an konkreten, praxisorientierten Übungsaufgaben umgesetzt. Im Rahmen der Übung wird das Projektgebiet während einer Exkursion besucht.

Lecture notes Prof. Dr. W.A. Schmid et al. (2006, Stand 2017): Raumplanung GZ - Eine Einführung für Ingenieurstudierende. IRL-PLUS, ETHZ

- Handouts of the lectures
- Exercises

Download: http://www.plus.ethz.ch/de/studium/vorlesungen/bsc/spatial_planning_and_landscap_evelopment.html

101-0515-00L Project Management W 2 credits 2G C. G. C. Marx

Abstract The course gives a detailed introduction on various aspects of professional project management out of theory and practice. Established concepts and methods for project organization, planning, execution and evaluation are introduced and major challenges discussed. The course includes an introduction on specialized project management software as well as agile project management concepts.

Objective Projects are not only the base of work in modern enterprises but also the primary type of cooperation with customers. Students of ETH will often work in or manage projects in the course of their career. Good project management knowledge is not only a guarantee for individual, but also for company wide success.

Content The goal of this course is to give a detailed introduction into project management. The students should learn to plan and execute a project.

- Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.
- Project planning (aims, appointments, capacities, efforts and costs), project organization, scheduling and risk analysis, project execution, supervision and control, project evaluation, termination and documentation, conflict management, multinational project management, IT support as well as agile project management methods such as SCRUM.

Lecture notes No. The lecture slides and other additional material will be available for download from Moodle a week before each class.

Specialization in an Environmental System

Atmosphere and Climate

The following courses are highly recommended as preparation for the Specialization in Atmosphere and Climate:

701-0106-00L Mathematik V: Angewandte Vertiefung von Mathematik I - III (Spring semester)
402-0048-00L Fortgeschrittene Physik für Umwelt- und ErdwissenschaftlerInnen (Spring semester)

These courses should be successfully completed during the second year.

Number Title Type ECTS Hours Lecturers
701-0459-00L Seminar for Bachelor Students: Atmosphere and Climate W 3 credits 2S R. Knutti, C. Brunner, O. Stebler

Abstract In this seminar all students in the realm of atmospheric and climate science from D-ERDW and D-USYS convene to train presentation techniques (talks, posters) by means of classic and modern scientific articles.

Objective In this seminar, students learn how to read scientific publications and how to transfer the scientific knowledge to a broader audience by means of oral and poster presentations. Students also get insight into the different research areas at the Institute for Atmospheric and Climate Science.

Content 1st week: course organisation and presentation of the institute
2nd and 3rd week: introduction to oral presentation technique
week 4 to 10: students talks
11th week: introduction to poster presentation technique
12th and 13th week: poster design
14th week: concluding poster presentation

Lecture notes Documents are offered via the course's web page.

Literature Documents are offered via the course's web page.

Prerequisites / notice This course can only be offered to a limited number of students, however, in any case for everybody having to attend it compulsory. We beg you to sign in to this course early.

Fostered competencies Subject-specific Competencies Concepts and Theories not assessed Techniques and Technologies not assessed

Method-specific Competencies Analytical Competencies not assessed Communication not assessed

Social Competencies Cooperation and Teamwork not assessed

Personal Competencies Sensitivity to Diversity not assessed Creative Thinking not assessed

701-0461-00L Numerical Methods in Environmental Physics W 3 credits 2G C. Schär, C. Zeman
This self-study course provides an introduction to atmospheric chemistry at bachelor level. It introduces the fundamentals of gas phase reactions, the concept of solubility and reactions in aerosols and in clouds. It explains the chemical and physical processes responsible for global (e.g. stratospheric ozone depletion) as well as regional environmental problems (e.g. urban air pollution).

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.

The concepts are applied to understand and judge the validity of different proposed artificial weather modification ideas.
Biogeochemistry

The following courses are highly recommended as preparation for the Specialization in Biogeochemistry:

701-0225-00L Organic Chemistry (Autumn semester)
752-0100-00L Biochemie (Autumn semester)
752-1300-00L Introduction to Toxicology (Spring semester)

These courses should be successfully completed during the second year.

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<td>W</td>
<td>3</td>
<td>2G</td>
<td>M. Sander, K. McNeill</td>
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<tr>
<td>Abstract</td>
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<td>- name and recognize the most important classes of environmentally relevant anthropogenic chemicals and identify chemical moieties governing their fate processes.</td>
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<td>- explain, on the basis of physical-chemical foundations, the most important processes (i.e., partitioning and substitution and elimination reactions) which determine the environmental behavior of organic pollutants.</td>
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<td>- identify, on the basis of chemical structure, the processes relevant for the environmental behavior of a compound.</td>
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<td>- critically evaluate published work and data.</td>
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<td>- Molecular interactions that determine the partitioning behavior (adsorption and absorption processes) of organic compounds between different environmental compartments (gas, liquid, solid)</td>
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<td>- Physical-chemical properties (vapor pressure, aqueous solubility, air-water partition constant, organic solvent-water partition constants, etc) and partitioning behavior of organic compounds between environmentally relevant phases (air, aerosols, soil, water, biota)</td>
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<tr>
<td>notice</td>
<td>Die Lehrveranstaltung richtet sich nicht nur an jene Studierenden, welche sich später chemisch vertiefen wollen, sondern ausdrücklich auch an alle jene, welche sich mit der Problematik von organischen Schadstoffen in der Umwelt vertraut machen wollen, um dieses Wissen in anderen Vertiefungen anzuwenden</td>
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<tr>
<td>701-0419-01L</td>
<td>Seminar for Bachelor Students: Biogeochemistry</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>D. I. Christ, A. N’Guyen van Chinh</td>
</tr>
<tr>
<td>Abstract</td>
<td>Current research topics are presented and discussed based on scientific literature. The students prepare a presentation with the support of an expert. Subsequently, the topics are discussed jointly by students and experts in student-moderated discussion rounds. Presentation and moderation techniques are presented and trained in the seminar, supported by instructions for constructive feedback.</td>
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<tr>
<td>Objective</td>
<td>The seminar aims at introducing the students to current research in the field of biogeochemistry and connect them with researchers. After the seminar, students are able to...</td>
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<td></td>
<td>- understand and critically evaluate original scientific papers and to communicate their findings in a coherent way (presentation); in doing so, they become familiar with different types of publications and relevant journals in the field of biogeochemistry;</td>
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<td>- discuss scientific results, plan and lead discussion rounds (moderation);</td>
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<td>- give and receive constructive feedback.</td>
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<tr>
<td>Content</td>
<td>Part 1: Literature search; presentation and moderation techniques.</td>
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<td>Part 2: Literature study; online-exchange of information; presentation and discussion moderated by students.</td>
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<tr>
<td>Lecture notes</td>
<td>Selected handouts will be distributed in class.</td>
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<tr>
<td>Prerequisites /</td>
<td><a href="https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php">https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php</a></td>
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<tr>
<td>notice</td>
<td>Restriction: only students enrolled in the environmental sciences bachelor's programm can register for this course.</td>
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<td>Deadline for enrollment is the FIRST day of the semester. Later enrollment can only be accepted in exceptional cases and under certain conditions (e.g., restricted choice of topics and dates).</td>
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<tr>
<td>Fostered</td>
<td>Subject-specific Competencies</td>
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<tr>
<td>competencies</td>
<td>Concepts and Theories</td>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Media and Digital Technologies</td>
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<td>Social Competencies</td>
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<td>Communication</td>
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<td>Personal Competencies</td>
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<td></td>
<td>Self-awareness and Self-reflection</td>
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</table>

701-0533-00L Soil and Water Chemistry W 3 credits 2G R. Kretzschmar, D. I. Christ, L. Winkel
This course covers chemical and biogeochemical processes in soils and water and their influence on the behavior and cycling of nutrients and pollutants in terrestrial and aquatic systems. Approaches for quantitative modeling of the processes are introduced and applied in selected examples.

1. Understanding of important chemical properties and processes of soils and water and their influence on the behavior (e.g., chemical speciation, bioavailability, mobility) of nutrients and pollutants.

2. Quantitative applications of chemical equilibria to processes in natural systems.

The course "Soil and Water Chemistry" teaches, applies and examines the competences process understanding, systems understanding, and modelling.

Chemical equilibria in aqueous solutions, gas equilibria, precipitation and dissolution of mineral phases, silicate weathering, weathering kinetics, formation of secondary minerals (clay minerals, oxides, sulfides), redox processes in natural systems, pH buffering and acidification, salinity and salinization, environmental behavior of selected essential and toxic trace elements.

Lecture notes, Literature & Prerequisites

Lecture slides on Moodle

--Chapters 1, 3, 4, 6, 7 and 11 in Sigg/Stumm – Aquatische Chemie, 6. Auflage, vdf, 2016.

The lecture courses Pedosphere and Hydrosphere are highly recommended.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>ECTS</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0535-00L</td>
<td>Environmental Soil Physics/Vadose Zone Hydrology</td>
<td>3 credits</td>
<td>A. Carminati, P. U. Lehmann Grunder</td>
</tr>
</tbody>
</table>

**Abstract**

The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/ near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

**Objective**

- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in pores

**Content**

- Week 1 (September 21): Introduction, content, structure of the course, objectives, bibliography, grading and evaluation; soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density.
- Week 2 (September 28): Pore scale consideration, pore sizes, shapes and connectivity, coordination number, continuity and percolation; surface tension; Young-Laplace equation; capillary rise; contact angle.
- Week 3 (October 05): Friction and laminar flow; Hagen-Poiseuille’s law; Washburn equation; numerical lab (including report)
- Week 4 (October 12): Soil water content; soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point.
- Week 5 (October 19): Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; Demo lab (including report)
- Week 6 (October 26): Saturated water flow in soils - Laminar flow in tubes (Poiseuille's Law); Darcy’s Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman); effective conductivity; unsaturated hydraulic conductivity; Buckingham law.
- Week 7 (November 02): Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow
- Week 8 (November 09): Numerical solution of Richards equation – Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)
- Week 9 (November 16): Solute and gas transport in soils - Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.
- Week 9 (November 23): Conductivity and resistance of soils – differences and similarities of hydraulic, electrical, thermal conductivities; Buckingham-Darcy, Fourier, and Archie’s law; pore scale characteristics and effective conductivities; soil thermal properties; steady state and non-steady heat flow
- Week 10 (November 30): Energy balance and land atmosphere interactions - Radiation and energy balance; evapotranspiration, potential and actual evaporation, definitions and estimation; evaporation stages and characteristic length
- Week 11 (December 07): Root water uptake and transpiration – Mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance
- Week 13 (December 14): Summary, questions, old exam
- Week 14 (December 21): Written Semester-end exam

**Literature**

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

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**Human-Environment Systems**

The following courses are highly recommended as preparation for the Specialization in Human-Environment Systems:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>ECTS</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>401-0625-01L</td>
<td>Applied Analysis of Variance and Experimental Design</td>
<td>3 credits</td>
<td>J. W. McCaughey, A. Berthold, D. N. Bresch, R. Garrett</td>
</tr>
<tr>
<td>701-0535-00L</td>
<td>Environmental Soil Physics/Vadose Zone Hydrology</td>
<td>3 credits</td>
<td>A. Carminati, P. U. Lehmann Grunder</td>
</tr>
<tr>
<td>401-0649-00L</td>
<td>Applied Statistical Regression; Prerequisite: 701-0105-00L Mathematics VI: Applied Statistics for Environmental Sciences</td>
<td>2 credits</td>
<td>A. Carminati, P. U. Lehmann Grunder</td>
</tr>
</tbody>
</table>

**Abstract**

Analysis and presentation of research papers from the involved chairs, relating to topics from human-environment systems.
The students learn to read, understand, summarize and present current research papers related to human-environment systems. Furthermore, students train the critical discussion of these papers. The students also get to know a number of innovative approaches for such presentations.

Research in human-environment systems is characterised by a broad range of topics and methods. This is illustrated by the research papers that are discussed in this seminar. Students choose a paper from a list and present it to the seminar participants. Furthermore, they lead the discussion and train questions and answers related to such presentations. In the first three lessons, inputs to presentation techniques and innovative approaches to presentations are provided and discussed.

**363-0537-00L**

**Resource and Environmental Economics**

- **W** 3 credits
- **2G** L. Bretschger

**Objective**

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at an international level, e.g. to the problem of climate change.

**Content**

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

**Literature**


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**401-0649-00L**

**Applied Statistical Regression**

- **W** 5 credits
- **2V+1U** M. Dettling

**Abstract**

This course offers a practically oriented introduction into regression modeling methods. The basic concepts and some mathematical background are included, with the emphasis lying in learning "good practice" that can be applied in every student's own projects and daily work life. A special focus will be laid in the use of the statistical software package R for regression analysis.

**Objective**

The students acquire advanced practical skills in linear regression analysis and are also familiar with its extensions to generalized linear modeling.

**Content**

The course starts with the basics of linear modeling, and then proceeds to parameter estimation, tests, confidence intervals, residual analysis, model choice, and prediction. More rarely touched but practically relevant topics that will be covered include variable transformations, multicollinearity problems and model interpretation, as well as general modeling strategies.

The last third of the course is dedicated to an introduction to generalized linear models: this includes the generalized additive model, logistic regression for binary response variables, binomial regression for grouped data and poisson regression for count data.

**Literature**

Faraway (2005): Linear Models with R
Faraway (2006): Extending the Linear Model with R
Draper & Smith (1998): Applied Regression Analysis
Fox (2008): Applied Regression Analysis and GLMs
Montgomery et al. (2006): Introduction to Linear Regression Analysis

**Prerequisites / notice**

The exercises, but also the classes will be based on procedures from the freely available, open-source statistical software package R, for which an introduction will be held.

In the Mathematics Bachelor and Master programmes, the two course units 401-0649-00L "Applied Statistical Regression" and 401-3622-00L "Statistical Modelling" are mutually exclusive. Registration for the examination of one of these two course units is only allowed if you have not registered for the examination of the other course unit.
Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>assessed</td>
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<td></td>
<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
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<td></td>
<td>Project Management</td>
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Social Competencies

<table>
<thead>
<tr>
<th>Communication</th>
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<tbody>
<tr>
<td>Cooperation and Teamwork</td>
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<tr>
<td>Customer Orientation</td>
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<tr>
<td>Leadership and Responsibility</td>
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<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
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<tr>
<td>Negotiation</td>
<td>not assessed</td>
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Personal Competencies

<table>
<thead>
<tr>
<th>Adaptability and Flexibility</th>
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<tbody>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
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<td>Critical Thinking</td>
<td>assessed</td>
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<td>Integrity and Work Ethics</td>
<td>assessed</td>
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<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td>not assessed</td>
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</tbody>
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851-0577-00L  Principles of Political Science  W  4 credits  2V+1U  T. Bernauer

Abstract

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

Objective

This course covers basic questions, concepts, theories, methods, and empirical findings of political science.

Content


Leistungskontrollen

a) Erster Test (...)
b) Zweiter Test (...)

Ergebnigemittelt das Ergebnis der benoteten Semesterleistung

Kreditpunkte

4 ECTS-Punkte (Zeitaufwand insgesamt ca. 120 Arbeitsstunden)

Lecture notes


Pro Kurseinheit (Woche) sind ca. 30–40 Seiten zu lesen. Für einzelne Kurseinheiten müssen Sie etwas mehr lesen (zwei Buchkapitel, ca. 60–80 Seiten insgesamt). Es lohnt sich also, bereits von Anfang des Kurses an ein wenig «auf Vorrat» zu lesen.

Weitere Lehrmaterialen finden Sie auf: http://www.ib.ethz.ch/teaching/pwgrundlagen
At the end of the course...

This course provides the ecological systems' knowledge needed to question applied sustainability solutions. We will critically assess the implications of current environmental issues, illustrating basic ecological concepts and principles. Our central aim is to balance participants' respect for complexity with a sense of possibility by providing examples from the vast solution space offered by ecological systems, such as e.g. green infrastructure to manage water.

...you have reflected on ecology as a young discipline at the heart of significant applied questions.

...you have an overview of the methods of ecosystem research and have a deeper insight into some of them, e.g. ecosystem observation, manipulation and modelling.

At the end of the course...

...you know how to structure your inquiry and how to proceed the analysis when faced with a complex environmental issue. You can formulate the relevant questions, find answers (supported by discussions, input from the lecturers and the literature), and you are able to present your conclusions clearly and cautiously.

...you understand the complexity of interactions and structures in ecosystems. You know how ecosystem processes, functions and services interact and feed back across multiple spatio-temporal scales (in general, plus in depth case examples).

...you understand that biodiversity and the interaction between organisms are an integral part of ecosystems. You are aware that the link between biodiversity and process/function/service is rarely fully understood. You know how to honestly deal with this lack of understanding and can nevertheless find, critically analyse and communicate solutions.

...you understand the importance of ecosystem services for society.

...you have an overview of the methods of ecosystem research and have a deeper insight into some of them, e.g. ecosystem observation, manipulation and modelling.

...you have reflected on ecology as a young discipline at the heart of significant applied questions.

The course is structured around four larger topical areas: (1) Integrated Water Management -- Green infrastructure (land management options) as an alternative to engineered solutions (e.g. large reservoirs) in flood and drought management; (2) Fire dynamics, the water cycle and biodiversity -- The surprising dynamics of species life cycles and populations in arid landscapes; (3) Rewilding, e.g. re-introducing apex predators (e.g. wolves), or large ungulates (e.g. bisons) in protected areas -- A nature conservation trend with counterintuitive effects; (4) Coupling of aquatic and terrestrial systems: carbon, nitrogen and phosphorus transfers of global importance on landscape scale.

These courses should be successfully completed during the second year.
It is not essential to borrow/buy the following books. We will continuously provide excerpts and other literature during the course.


Schulze et al. (2005) Plant Ecology; Springer.

The course combines elements of a classic lecture, group discussions and problem based learning. It is helpful, but not essential to be familiar with the "seven stages" method (see e.g. course 701-0352-00L "Analysis and Assessment of Environmental Sustainability" by Christian Pohl et al.).

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Type</th>
<th>Credits</th>
<th>Schedule</th>
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<tbody>
<tr>
<td>701-0320-00L</td>
<td>Seminar for Bachelor Students: Environmental Biology</td>
<td>W</td>
<td>3</td>
<td>2S</td>
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<tr>
<td>701-0371-00L</td>
<td>Ecosystem Conservation and Restoration</td>
<td>W</td>
<td>3</td>
<td>2G</td>
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</table>

Abstract

In the seminar, students explore a specific topic in environmental biology (ecology, evolution, health). They find and read scientific articles, structure contents around core questions, talk to specialists about them, prepare a scientific presentation and lead a discussion. They are introduced to literature search and scientific presentations.

Objective

Students will acquire skills in:
- finding literature in scientific databases
- structuring a scientific topic through research questions
- giving a clear scientific presentation
- contributing constructively to a scientific discussion

Content

Week 1: Choice of topics and tutors
Week 2, 3 or 4: Literature search and Presentation Techniques workshop
Weeks 1 - 5: Meetings with tutors, preparation of presentations
Weeks 5 - 14: Presentations and discussions

Lecture notes

Will be handed out during classes

Fostered competencies

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<th>Method-specific Competencies</th>
<th>Social Competencies</th>
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<td>Concepts and Theories</td>
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<td>Self-direction and Self-management</td>
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Abstract

Conservation and restoration are interdisciplinary sciences that nonetheless are founded on fundamental ecological concepts. The course will explore theoretical underpinnings of conservation and restoration science that inform planning and implementation, and consequent outcomes. New concepts and emerging technologies will be explored, alongside case studies that inform discussions.

Objective

Through the course, students will:
- Understand the theoretical underpinnings of conservation and restoration science.
- Consider alternative conservation concepts and approaches, and the role of science and evidence in implementing these ideas in practice.
- Appraise different conservation strategies, drawing on case studies and examples from around the world.
- Explore new and emerging technologies that can be useful to guide responsible decision making in land management decisions.
- Evaluate the future direction of conservation science, in terms of new concepts (resilience, restoration, rewilding, natural capital, de-extinction) and emerging technologies (remote sensing, AI, genetics).
- Explore conservation and restoration science and practice in the context of current societal pressures, and the prospects for biodiversity conservation in coming decades.
- Understand how responsible restoration and conservation goals should integrate local practices, customs, cultures, and economic requirements.

In this course, students will:
- Learn about the historical development of thinking in conservation and restoration ecology
- Learn about the ecological theories underpinning conservation and restoration ecology
- Learn about emerging statistical and analytical tools to guide effectively responsible conservation and restoration initiatives
- Learn about the practical challenges and trade-offs in decision making that ultimately govern the success of conservation and restoration challenges around the world
- Understand, through the exploration of case studies and site visits, differing normative and management perspectives on landscape scale conservation and restoration.
2021 marks the start of the UN Decade on ecosystem restoration, a global initiative to conserve and restore nature for the benefit or climate change, biodiversity and human wellbeing. As an emerging workforce enters this exponentially growing field, we hope that they will be armed with the fundamental principles that are necessary to enhance the likelihood of success.

Conservation and restoration science is a relatively young discipline, yet it has undergone substantial change in recent decades on account of changing environmental realities, new conceptual framings, and opportunities afforded by emerging technologies. As a rapidly evolving discipline, with considerable relevance and impact to environment, policy, and society, it is essential that environmental science students understand the role of science for conservation practice.

This course will explore how science and technology provides the conceptual structure and knowledge base for new approaches to conservation of biodiversity, habitats, and resources. The course will begin by examining the theoretical foundations of conservation science, and how these concepts have developed over the past century. It will examine alternative approaches to conservation ranging from traditional protected area and wildlife management systems, through to more recent concepts and approaches, including ecosystem services, natural capital, restoration, and rewilding. It will emphasize the role of new technological and analytical methods, including Earth observation, monitoring systems, AI, and genetics. Finally, the students will use a horizon scanning approach to determine the future opportunities, priorities, and constraints for conservation science and practice in our rapidly changing world.

Students will evaluate several general questions, including:
- What is conservation, and what do we want to conserve?
- What ecological theories frame conservation and restoration practice, and how can science guide conservation decisions?
- What concepts (ecological, societal, economical) shape conservation and restoration theory and practice, and what conflicts do they engender?
- What prospects does technology offer for future conservation and restoration efforts?

Ecosystems Conservation and Restoration will provide an excellent foundation on how theoretical and applied natural and social sciences are, and can be, coupled to emerging technologies and data science to conserve and restore biodiversity and ecological functions in landscapes. For students wishing to acquire a deeper level of understanding of both science and practice in conservation and restoration, this course will serve as the prerequisite for a two-week Masters-level field course (tentatively titled Conservation, Restoration, and Landscape Management) to Scotland, being developed by the Ghazoul and Crowther labs and planned for 2023. The field course will challenge students to apply the conceptual and technical understanding gained from the Ecosystem Conservation and Restoration course, specifically by working with a variety of stakeholders involved in selected forest and landscape restoration processes in Scotland.

### Literature

Current literature will be provided in due course

#### 701-1413-00L Population and Quantitative Genetics

**Abstract**

This course is an introduction to the rapidly developing fields of population and quantitative genetics, emphasizing the major concepts and ideas over mathematical formalism. An overview is given of how mutation, genetic drift, gene flow, mating systems, and selection affect the genetic structure of populations. Evolutionary processes affecting quantitative and Mendelian characters are discussed.

**Objective**

Students are able to:
- describe types and sources of genetic variation.
- describe fundamental concepts and methods of quantitative genetics.
- use basic mathematical formalism to describe major population genetic concepts.
- discuss major topics and developments in population and quantitative genetics.
- model population genetic processes using specific computer programs.

**Content**

Population Genetics:
- Types and sources of genetic variation; randomly mating populations and the Hardy-Weinberg equilibrium; effects of inbreeding; natural selection; random genetic drift and effective population size; gene flow and hierarchical population structure; molecular population genetics: neutral theory of molecular evolution and basics of coalescent theory.

Quantitative Genetics:
- Continuous variation; measurement of quant. characters; genes, environments and their interactions; measuring their influence; response to selection; inbreeding and crossesbreeding, effects on fitness; Fisher's fundamental theorem.

**Lecture notes**

Handouts

**Literature**


#### 701-1413-01L Ecological Genetics

**Abstract**

This course focuses on fundamental concepts and methods in ecological genetics. Topics covered include genetic diversity, natural selection, adaptation, reproductive isolation, hybridization and speciation.

**Objective**

Students are familiar with fundamental concepts in ecological genetics and with current scientific methods. They can propose strategies to study evolutionary processes in natural populations by combining their knowledge from different disciplines, including population and quantitative genetics, ecology and evolution.

**Content**

Concepts and methods for the study of genetic diversity, biodiversity, natural selection, adaptation, reproductive isolation, hybridization and speciation.

**Lecture notes**

Handouts will be provided electronically.

**Prerequisites / notice**

We recommend that you also follow the course 701-1413-00L - Population and Quantitative Genetics either in advance or in parallel.

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### Forest and Landscape

The following courses are highly recommended as preparation for the Specialization in Forest and Landscape:

- **701-0266-00L Einführung in die Dendrologie (Autumn semester)**
- **701-0951-00L GISD - Einführung in die räumlichen Informationswissenschaften und -technologien (Autumn Semester)**
- **551-0448-00L Zoologie (Spring semester)**
- **701-0360-00L Systematische Biologie: Pflanzen (Spring semester)**

These courses should be successfully completed during the second year.

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#### 701-0535-00L Environmental Soil Physics/Vadose Zone Hydrology

**Abstract**

The course provides theoretical and practical foundations for understanding and characterizing physical and transport properties of soils/near-surface earth materials, and quantifying hydrological processes and fluxes of mass and energy at multiple scales.

**Objective**

Students are able to:
- characterize porous media at different scales
- parameterize structural, flow and transport properties of partially-saturated porous media
- quantify driving forces and resulting fluxes of water, solute, and heat in soils

**Lecturers**

A. Carminati, P. U. Lehmann Grunder
The course is an introduction to Landscape Ecology and Landscape Modelling and provides various practical applications of Landscape Ecology in nature and landscape management.

The students are able to:
- explain and apply the concepts and methods of landscape analysis using examples,
- to explain causes and effects of changes in landscape using examples and simulations,
- to describe practical applications of Landscape Ecology in the management of nature and landscape.

Contents of the lecture:
- important terms and concepts of Landscape Ecology,
- analysis of landscape pattern (metrics),
- landscape modelling,
- perception of landscapes,
- landscape inventories used for nature and landscape protection.

The course is offered via a MOOC (Edx) and the supplemental textbook (not mandatory) is "Introduction to Environmental Soil Physics, by: D. Hillel, M. Lévesque"

Seminar for Bachelor Students: Forest and Landscape
Interdisciplinary seminar on forest and landscape issues with particular emphasis on the key processes shaping the development of forest ecosystems and landscapes.

Objectives:
- To critically analyze and discuss original scientific articles for selected processes and methods in relation to forest and landscape.
- Scientific exchange with subject-specific experts.
- Effective feedback regarding the independent development of presentation and moderation competencies.

Content:
Seminars will deal with the following topics: 1) Biological, ecological and physical processes, and technical aspects in forest ecosystems with effects on the community, ecosystem and landscape; 2) Social and political processes and institutions with relation to land use; 3) Products and services of forest ecosystems and landscapes and 4) Forest management systems. The contributions will be grouped by topics. Furthermore, the seminar teaches rhetoric and moderation methods, which will serve to deepen the above topics through presentations and discussions.

Lecture notes:
There will be a script for the rhetoric and moderation methods.

Literature:
Literature references will be provided by the lecturers.

Prerequisites / notice:
- a) Independent literature research on the topic and exchange with experts for preparing for the presentation
- b) Presentation with questions and answers (15-20 min)
- c) Moderation of the scientific discussion (20-35 min)
- d) Actively contributing to the feedback of students' presentations, moderation and discussions.

The presentations can be made in German or English.
We expect a regular and active participation.
This course conveys the basics of forest ecology with an emphasis on trees as those organisms that dominate the physiognomy and the dynamics of forest ecosystems. Based on this course, students have a good grasp of the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with a focus on central Europe.

Students are able to summarize the fundamentals of forest ecology at the autecological, demecological and synecological level, explain how trees dominate the physiognomy and dynamics of forest ecosystems, describe the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with an emphasis on central Europe and Alpine region.

Overall, the competences of process understanding, system understanding, modeling, concept development and data analysis & interpretation are taught and examined in this course.

Introduction and overview of the forests of the world
Forest ecosystem ecology; Production ecology of forests
Autecology: light, temperature, wind, water, and nutrients
Demecology: regeneration ecology, forest growth, mortality
Synecology: fundamentals of trophic interactions (forest-ungulate interactions), succession

Handouts (mixture of overhead slides and full text chapters) are sold at cost

Relevant chapters from textbooks will be indicated.

This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.

By the end of the course, students will be able to explain the main natural hazards, their processes and their importance in different contexts. describe the likelihood, risk, and consequences of natural hazards and their management options. identify and discuss the development of natural hazards in the context of climate change. develop, formulate and present solutions to these challenges to a critical audience.

This course covers the diversity, biology and ecology of insects and pathogens, both native and non-native species and especially those that are tree pests or cause diseases. The course also covers entomological and pathological methods, forest protection and other relevant topics.

By the end of the course, students have a good grasp of the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with a focus on central Europe.

Insects and microorganisms are important components of the biodiversity and ecology of forests. This course covers the diversity, biology and ecology of insects and pathogens, both native and non-native species and especially those that are tree pests or cause diseases. The course also covers entomological and pathological methods, forest protection and other relevant topics.

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By the end of the course, students have a good grasp of the qualitative and quantitative importance of forest ecosystems at the global and regional scales, with a focus on central Europe.
By developing the bachelor's thesis, students learn to (a) analyse a problem using scientific methods and concepts, (b) write a report according to scientific standards and (c) correctly cite scientific literature. Depending on the chosen orientation of the thesis, the students learn these skills through an empirical analysis, a literature review, via design tasks or through an applied project.

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A bachelor's thesis in "Natural sciences" deals with the environmental effects of use and application. The thesis may take the form of an analysis or review of a current technology, or the design of a future technological application. In an inter- or transdisciplinary thesis, knowledge from various fields and disciplines would be merged on the basis of an overarching question, or developed via the input of key societal actors. A bachelor's thesis should consist of a text, with graphs and figures, of 15-20 pages.

A short bachelor's thesis should consist of a text, with graphs and figures, of 15-20 pages.

A bachelor's thesis in "Technology" deals with the environmental effects of use and application. The thesis may take the form of an analysis or review of a current technology, or the design of a future technological application. In an inter- or transdisciplinary thesis, knowledge from various fields and disciplines would be merged on the basis of an overarching question, or developed via the input of key societal actors. A bachelor's thesis should consist of a text, with graphs and figures, of 30-40 pages.

A bachelor's thesis in "Natural sciences" deals with the environmental effects of use and application. The thesis may take the form of an analysis or review of a current technology, or the design of a future technological application. In an inter- or transdisciplinary thesis, knowledge from various fields and disciplines would be merged on the basis of an overarching question, or developed via the input of key societal actors. A bachelor's thesis should consist of a text, with graphs and figures, of 30-40 pages.
## Prerequisites

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>701-0471-01L</td>
<td>Atmospheric Chemistry</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>M. Ammann, T. Peter</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>This self-study course provides an introduction to atmospheric chemistry at bachelor level. It introduces the fundamentals of gas phase reactions, the concept of solubility and reactions in aerosols and in clouds. It explains the chemical and physical processes responsible for global (e.g. stratospheric ozone depletion) as well as regional environmental problems (e.g. urban air pollution).</td>
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<td></td>
<td>The students will understand the basics of gas phase reactions and of reactions and processes in aerosols and clouds. The students will understand the most important chemical processes in the troposphere and the stratosphere.</td>
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<td></td>
<td>- Origin and properties of structure: large scale dynamics, UV radiation</td>
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<td></td>
<td>- Thermodynamics and kinetics of gas phase reactions: enthalpy and free energy of reactions, rate laws, mechanisms of bimolecular and termolecular reactions.</td>
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<td></td>
<td>- Tropospheric photochemistry: Photolysis reactions, photochemical O3 formation, role and budget of NOx, dry and wet deposition</td>
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<td></td>
<td>- Aerosols and clouds: chemical properties, primary and secondary aerosol sources, phase transfer kinetics, solubility and hygroscopicity, N2O5 chemistry, SO2 oxidation, secondary organic aerosols</td>
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<td>- Air quality: role of planetary boundary layer, summer- versus winter-smog, environmental problems, legislation, long-term trends</td>
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<td>- Stratospheric chemistry: Chapman cycle, Brewer-Dobson circulation, catalytic ozone destruction cycles, polar ozone hole, Montreal protocol</td>
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<td>- Global aspects: global budgets of ozone, methane, CO and NOX. air quality - climate interactions</td>
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<td>Lecture notes / notice</td>
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<td>Lecture materials (slides and annotations) of the most recent corresponding bachelor course are provided.</td>
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<td>701-0473-00L</td>
<td>Weather Systems</td>
<td>W</td>
<td>3 credits</td>
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<td>M. A. Sprenger, F. Scholader-Aemisegger</td>
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<td>Abstract</td>
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<td></td>
<td>Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north-atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; Potential Vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer; water isotopes</td>
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<td>The students are able to</td>
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<td></td>
<td>- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics</td>
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<td>- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena</td>
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<td>- explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features</td>
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<td>- to explain how mountains influence the atmospheric flow on different scales</td>
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<td>- basic understanding of stable water isotopes as tracers for moist adiabatic processes in weather systems</td>
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<td>Lecture notes / notice</td>
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<td>Lecture notes and slides</td>
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<td>Literature</td>
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<td></td>
<td>Atmospheric Science, An Introductory Survey</td>
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<td></td>
<td>John M. Wallace and Peter V. Hobbs, Academic Press</td>
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<tr>
<td>701-0475-00L</td>
<td>Atmospheric Physics</td>
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<td>3 credits</td>
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<td>Abstract</td>
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<td></td>
<td>This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation especially prediction of thunderstorm development, aerosol physics as well as artificial weather modification.</td>
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<td>Students are able</td>
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<td>- to explain the mechanisms of thunderstorm formation using knowledge of thermodynamics and cloud microphysics.</td>
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<td>- to evaluate the significance of clouds and aerosol particles for artificial weather modification.</td>
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<td>n the course &quot;Atmospheric Physics&quot;, the competencies of process understanding, system understanding and data analysis &amp; interpretation are taught, applied and examined. The competence measurement methods is taught as well.</td>
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<td>The course starts with introducing selected concepts of thermodynamics for atmospheric processes: The students learn the concept of the thermodynamic equilibrium and derive the Clausius-Clayperon equation from the first law of thermodynamics. This equation is central for the phase transitions in clouds.</td>
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<td>Students also learn to classify radiosondes with the help the thermodynamic charts (tephigrams) and to identify cloud base, cloud top, available convective energy in them. Atmospheric mixing processes are introduced for fog formation. The concept of the air parcel is used to understand convection.</td>
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<td>Aerosol particles are introduced in terms of their physical properties and their role in cloud formation based on Köhler theory. Thereafter cloud microphysical processes including ice nucleation are discussed.</td>
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<td>With these basics, the different forms of precipitation formation (convective vs. stratiform) is discussed as well as the formation and different stages of severe convective storms.</td>
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<td>The concepts are applied to understand and judge the validity of different proposed artificical weather modification ideas.</td>
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<td>Lecture notes / notice</td>
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<td>Powerpoint slides and chapters from the textbook will be made available on moodle: <a href="https://moodle-app21.let.ethz.ch/course/view.php?id=15367">https://moodle-app21.let.ethz.ch/course/view.php?id=15367</a></td>
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<td>Literature</td>
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<td>Prerequisites / notice</td>
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<td>For certain capters we'll use the concept of &quot;flipped classroom&quot; (en.wikipedia.org/wiki/Flipped_classroom), which we introduce at the beginning.</td>
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<td>We offer a lab tour, in which we demonstrate how some of the processes discussed in the lectures are measured with instruments.</td>
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<td>There is a additional tutorial right after each lecture to give you the chance to ask further questions and discuss the exercises. The participation is recommended but voluntary.</td>
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</table>
The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.


H. Joos, T. Peter
3 credits

In this seminar, the process of writing a scientific proposal will be

Lecturers
Colloquium Atmosphere and Climate 1
This lecture conveys the mathematical basis necessary for the development and application of numerical models in the field of Environmental Science. The lecture material includes an introduction into numerical techniques for solving ordinary and partial differential equations, as well as exercises aimed at the realization of simple models using the computer language Python.

Objective
Ability to develop simple numerical schemes and to implement these schemes using the programming language Python. Ability to critically use more complex numerical models.

Content
Classification of numerical problems, introduction to finite-difference methods, linear and nonlinear transport equation, time integration schemes, non-linearity, conservative numerical techniques, overview of other methods. Examples and exercises from a diverse cross-section of Environmental Science.

Three exercises, each two hours in length, are integrated into the lecture. The implementation language is Python (previous experience not necessary, a Python introduction is provided). Example programs and graphics tools are supplied.

Lecture notes

Literature
List of literature is provided.

➡️ Mandatory Courses
➡️➡️ Introduction Course

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<th>Lecturers</th>
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<tr>
<td>701-1213-00L</td>
<td>Introduction Course to Master Studies Atmosphere and Climate</td>
<td>O</td>
<td>2</td>
<td>2G</td>
<td>H. Joos, T. Peter</td>
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</tbody>
</table>

Abstract
New master students are introduced to the atmospheric and climate research field through keynotes given by the programme's professors. In several self-assessment and networking workshops they get to know each other and obtain general information and guidance about the organisation of the MSc programme.

Objective
The aims of this course are i) to welcome all students to the master program and to ETH, ii) to acquaint students with the faculty teaching in the field of atmospheric and climate science at ETH and at the University of Bern, iii) that the students get to know each other and iv) to assess needs and discuss options for training and eduction of soft-skills during the Master program and to give an overview of the study options in general

➡️➡️ Colloquia

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<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
The colloquium is a series of scientific talks by prominent invited speakers assembling interested students and researchers from around Zürich. Students take part of the scientific discussions.

Objective
The students are exposed to different atmospheric science topics and learn how to take part in scientific discussions.

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➡️➡️ Seminars

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1211-01L</td>
<td>Master's Seminar: Atmosphere and Climate 1</td>
<td>O</td>
<td>3</td>
<td>2S</td>
<td>H. Joos, R. Knutti, A. Merrifield Kötz, M. A. Wüest</td>
</tr>
</tbody>
</table>

Abstract
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and class exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other's work.

Objective
Training scientific writing skills.
In this seminar, the process of writing a scientific proposal will be introduced. The essential elements of a proposal, including the peer review process, will be outlined and classic exercises will train scientific writing skills. Knowledge exchange between class participants is promoted through the preparation of a master thesis proposal and evaluation of each other’s work.

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<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>H. Wernli, L. Papritz</td>
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<td></td>
<td>Abstract</td>
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<td></td>
<td>This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (quantitative and qualitative) form an essential part of the course.</td>
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<td></td>
<td>Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.</td>
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<td>Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.</td>
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<td>Lecture notes</td>
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<td>Dynamics of large-scale atmospheric flow</td>
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<td>Literature</td>
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<td></td>
<td>- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997</td>
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<td>Prerequisites / notice</td>
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<tr>
<td></td>
<td>Physics I, II, Environmental Fluid Dynamics</td>
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<tr>
<td>651-4053-05L</td>
<td>Boundary Layer Meteorology</td>
<td>W</td>
<td>4</td>
<td>3G</td>
<td>M. Rotach, P. Calanca</td>
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<td>Abstract</td>
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<td>The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.</td>
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<td>Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).</td>
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<td>- Introduction</td>
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<td>- Turbulence</td>
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<td>- Statistical tratment of turbulence, turbulent transport</td>
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<td>- Conservation equations in a turbulent flow</td>
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<td>- Closure problem and closure assumptions</td>
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<td>- Scaling and similarity theory</td>
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<td></td>
<td>- Spectral characteristics</td>
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<td></td>
<td>- Concepts for non-ideal boundary layer conditions</td>
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<td></td>
<td>Lecture notes</td>
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<td>available (i.e. in English)</td>
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<td></td>
<td>Literature</td>
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<td>Prerequisites / notice</td>
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<td></td>
<td>Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science</td>
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In this seminar, scientific project management is introduced and applied to the master projects. The course concludes with a presentation of all projects including an overview of the scientific content and a discussion of project management techniques related to the master thesis.

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<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1235-00L</td>
<td>Cloud Microphysics</td>
<td>W</td>
<td>4</td>
<td>2V+1U</td>
<td>Z. A. Kanji, N. Shardt, Y. Wang</td>
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<td></td>
<td>Number of participants limited to 20.</td>
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<td>The lecture takes place if a minimum of 7 students register for it.</td>
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<td></td>
<td>Priority is given to PhD students majoring in Atmospheric and Climate Sciences, and remaining open spaces will be offered to the following groups:</td>
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<td></td>
<td>- PhD student Environmental sciences</td>
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<td></td>
<td>- MSc in Atmospheric and climate science</td>
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<tr>
<td></td>
<td>- MSc in Environmental sciences</td>
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<td></td>
<td>All participants will be on the waiting list at first. Enrollment is possible until 14.09.2022. All students will be informed on 15./16.09.2022, if they can participate in the lecture.</td>
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Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2238 of 2416
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.

This course will be designed as a reading course in 1-2 small groups of 10 students maximum. It will be based on the textbook below. The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth.

Lamb and Verlinde: PHYSICS AND CHEMISTRY OF CLOUDS, Cambridge University Press, 2011

The purpose of this course is to provide fundamental background on the role of land surface processes (vegetation, soil moisture dynamics, land energy, water and carbon balances) in the climate system. The course consists of 2 contact hours per week, including lectures, group projects and computer exercises.

The students will also acquire a good understanding of the coupling between stratospheric ozone and climate change.

The target groups are the following:
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.

The lecture gives an overview on the manifold reactions which occur in the gas phase, in stratospheric aerosol droplets and in polar cloud particles. The focus is on the chemistry of stratospheric ozone and its influence through natural and anthropogenic effects, especially the ozone depletion caused by FCKW in mid-latitude and polar regions as well as the coupling with the greenhouse effect.

The students will also acquire a good understanding of the coupling between stratospheric ozone and climate change.

Furthermore, they will be able to explain fundamental concepts in stratospheric chemistry by means of scientific paper presentations.

Documents are provided in the contact hours.


Prerequisites: Basics in physical chemistry are required and an overview equivalent to the bachelor course in atmospheric chemistry (lecture 701-0471-01) is expected.

701-1251-00L Land-Climate Dynamics

W 3 credits 2G S. I. Seneviratne,
R. Padrón Flasher, P. Sieber

Number of participants limited to 36.

The target groups are the following:
- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

Prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth.


The waiting list is active until 30.09.2022
Objective  

Physical and chemical principles:  
The students...  
- know the processes and physical laws of aerosol dynamics.  
- understand the thermodynamics of phase equilibria and chemical equilibria.  
- know the photo-chemical formation of particulate matter from inorganic and organic precursor gases.

Experimental methods:  
The students...  
- know the most important chemical and physical measurement instruments.  
- understand the underlying chemistry and physics.

Environmental impacts:  
The students...  
- know the major sources of atmospheric aerosols, their chemical composition and key physical properties.  
- know the most important climate impacts of atmospheric aerosols.

Fostered competencies  

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Techniques and Technologies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
</tr>
<tr>
<td>assessed</td>
<td>not assessed</td>
<td>Customer Orientation</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>not assessed</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>assessed</td>
<td>not assessed</td>
<td>Self-presentation and Social Influence</td>
<td>Integrity and Work Ethics</td>
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<tr>
<td>assessed</td>
<td>not assessed</td>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
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<tr>
<td>assessed</td>
<td>not assessed</td>
<td>Negotiation</td>
<td>Self-direction and Self-management</td>
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<tr>
<td>assessed</td>
<td>not assessed</td>
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<td>assessed</td>
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Climate History and Paleoclimatology  

Objective  

The course spans 5 thematic modules:

1. Cyclic variation in the earth's orbit and the rise and demise of ice sheets. Ice sheets and sea level - What do expansionist glaciers want? What is the natural range of variation in the earth's ice sheets and the consequent effect on sea level? How do cyclic variations in the earth's orbit affect the size of ice sheets under modern climate and under past warmer climates? What conditions the mean size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

2. Feedbacks on climate cycles from CO2 and methane. What drives CO2 and methane variations over glacial cycles? What are the feedbacks with ocean circulation and the terrestrial biosphere?

3. Atmospheric circulation and variations in the earth's hydrological cycle - How variable are the earth's precipitation regimes? How large are the orbital scale variations in global monsoon systems?

4. Century-scale droughts and civil catastrophes. Will mean climate change El Nino frequency and intensity? What factors drive change in mid and high-latitude precipitation systems? Is there evidence that changes in water availability have played a role in the rise, demise, or dispersion of past civilizations?

5. How sensitive is Earth's long term climate to CO2 and cloud feedbacks? What regulates atmospheric CO2 over long tectonic timescales of millions to tens of millions of years?

The weekly two hour lecture periods will feature lecture on these themes interspersed with short interactive tasks to apply new knowledge. Over the semester, student teams will each present in class one debate based on two scientific articles of contrasting interpretations. With flexible scheduling, students will participate in a laboratory activity to generate a new paleoclimatic record from stalagmites. Student teams will be supported by an individual tutorial meeting to assist in debate preparation and another to assist in the interpretation of the lab activity data.

Lecture notes  

Material is distributed during the lecture.
<table>
<thead>
<tr>
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<th>Lecturers</th>
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<tbody>
<tr>
<td>701-1251-00L</td>
<td>Land-Climate Dynamics</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>S. I. Seneviratne, R. Padrón Flasher, P. Sieber</td>
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<td>Number of participants limited to 36.</td>
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<td>- MSc in Environmental sciences</td>
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<td>Priority is given to the target groups until 19.09.2022. The waiting list is active until 02.10.2022.</td>
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<td>Objective</td>
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<td></td>
<td>The students can understand the role of land processes and associated feedbacks in the climate system.</td>
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<td>Lecture notes</td>
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<td>Powerpoint slides will be made available</td>
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<td>Prerequisites / notice</td>
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<tr>
<td></td>
<td>Prerequisites: Introductory lectures in atmospheric and climate science</td>
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<tr>
<td>701-1253-00L</td>
<td>Analysis of Climate and Weather Data</td>
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<td>2G</td>
<td>C. Frei</td>
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<td></td>
<td>Abstract</td>
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<td>An introduction into methods of statistical data analysis in meteorology and climatology. Applications of hypothesis testing, extreme value analysis, evaluation of deterministic and probabilistic predictions, principal component analysis. Participants understand the theoretical concepts and purpose of methods, can apply them independently and know how to interpret results professionally.</td>
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<td>Students understand the theoretical foundations and probabilistic concepts of advanced analysis tools in meteorology and climatology. They can conduct such analyses independently, and they develop an attitude of scrutiny and an awareness of uncertainty when interpreting results. Participants improve skills in understanding technical literature that uses modern statistical data analyses.</td>
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<td>The course introduces several advanced methods of statistical data analysis frequently used in meteorology and climatology. It introduces the theoretical background of the methods, illustrates their application with example datasets, and discusses complications from assumptions and uncertainties. Generally, the course shall empower students to conduct data analysis thoughtfully and to interpret results critically.</td>
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<td>Topics covered: exploratory methods, hypothesis testing, analysis of climate trends, measuring the skill of deterministic and probabilistic predictions, analysis of extremes, principal component analysis and maximum covariance analysis.</td>
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<td>The course is divided into lectures and computer workshops. Hands-on experimentation with example data shall encourage students in the practical application of methods and train professional interpretation of results.</td>
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<td>R (a free software environment for statistical computing) will be used during the workshop. A short introduction into R will be provided during the course.</td>
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<td>Lecture notes</td>
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<td>Documentation and supporting material:</td>
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<tr>
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<td>- slides used during the lecture</td>
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<td>- exercise sets and solutions</td>
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<td>- R-packages with software and example datasets for workshop sessions</td>
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<td>All material is made available via the lecture web-page.</td>
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<td>Literature</td>
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<td>For complementary reading:</td>
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<td>Prerequisites / notice</td>
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<td>Prerequisites: Basics in exploratory data analysis, probability calculus and statistics (incl linear regression) (e.g. Mathematik IV: Statistik (401-0624-00L) and Mathematik VI: Angewandte Statistik für Umwelt- und Naturwissenschaften (701-0105-00L)). Some experience in programming (ideally in R). Some elementary background in atmospheric physics and climatology.</td>
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<tr>
<td>102-0468-10L</td>
<td>Watershed Modelling</td>
<td>W</td>
<td>6</td>
<td>4G</td>
<td>P. Molnar</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Watershed Modelling is a practical course on numerical water balance models for a range of catchment-scale water resource applications. The course covers GIS use in watershed analysis, models types from conceptual to physically-based, parameter calibration and model validation, and analysis of uncertainty. The course combines theory (lectures) with a series of practical tasks (exercises).</td>
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<td>Objective</td>
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<td>The main aim of the course is to provide practical training with watershed models for environmental engineers. The course is built on thematic lectures (2 hrs a week) and practical exercises (2 hrs a week). Theory and concepts in the lectures are underpinned by many examples from scientific studies. A comprehensive exercise block builds on the lectures with a series of 4 practical tasks to be conducted during the semester in group work. Exercise hours during the week focus on explanation of the tasks. The course is evaluated 50% by performance in the graded exercises and 50% by a semester-end oral examination (30 mins) on watershed modelling concepts.</td>
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<td>Content</td>
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<td>The first part (A) of the course is on watershed properties analysed from DEMs, and on global sources of hydrological data for modelling applications. Here students learn about GIS applications (ArcGIS, Q-GIS) in hydrology - flow direction routines, catchment morphometry, extracting river networks, and defining hydrological response units. In the second part (B) of the course on conceptual watershed models students build their own simple bucket model (Matlab, Python), they learn about performance measures in modelling, how to calibrate the parameters and how to validate models, about methods to simulate stochastic climate to drive models, uncertainty analysis. The third part (C) of the course is focussed on physically-based model components. Here students learn about components for soil water fluxes and evapotranspiration, they practice with a fully-distributed physically-based model Topkapi-ETH, and learn about other similar models at larger scales. They apply Topkapi-ETH to an alpine catchment and study simulated discharge, snow, soil moisture and evapotranspiration spatial patterns.</td>
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<td></td>
<td>Lecture notes</td>
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<td></td>
<td>There is no textbook. Learning materials consist of (a) video-recording of lectures; (b) lecture presentations; and (c) exercise task documents that allow independent work.</td>
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<tr>
<td></td>
<td>Literature</td>
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<tr>
<td></td>
<td>Literature consist of collections from standard hydrological textbooks and research papers, collected by the instructors on the course moodle page.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td></td>
<td>Basic Hydrology in Bachelor Studies (engineering, environmental sciences, earth sciences), Basic knowledge of Matlab (Python), ArcGIS (Q-GIS).</td>
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</tbody>
</table>
Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies assessed
Problem-solving not assessed

Method-specific Competencies
Analytical Competencies assessed

Social Competencies
Communication not assessed
Cooperation and Teamwork assessed

Personal Competencies
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection not assessed
Self-direction and Self-management not assessed

651-4053-05L Boundary Layer Meteorology Z 4 credits 3G M. Rotach, P. Calanca

Abstract
The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective
Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

Content
- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes available (i.e. in English)

Literature

Prerequisites / notice
Umwelt-Fluiddynamik (701-0479-00L) (environment fluid dynamics) or equivalent and basic knowledge in atmospheric science

Electives
Weather Systems and Atmospheric Dynamics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-1281-00L</td>
<td>Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS)</td>
<td>W</td>
<td>3</td>
<td>6A</td>
<td>Supervisors</td>
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</tbody>
</table>

Abstract
This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:
- atmospheric chemistry
- atmospheric dynamics
- atmospheric physics
- climate modeling
- climate physics
- land-climate dynamics
- atmospheric circulation
- paleoclimate
- ocean biogeochemical dynamics

Objective
The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

Content
The course has the following elements:
Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
Week 2: General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University:
https://www.coursera.org/learn/sciwrite?action=enroll
Weeks 6 and 9: Meetings with supervisor to clarify scientific questions
Week 12: Hand-in of written summary (4 pages maximum)
Week 14: Supervisor provides written feedback to the summary document
Week 16: Oral exam about the scientific topic

Literature
Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.
Prerequisites / notice
Prerequisites depend on the chosen field and include successful completion of the listed lecture courses:
- atmospheric dynamics: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- atmospheric chemistry: “Stratospheric Chemistry” (701-1233-00L) or “Tropospheric Chemistry” (701-1234-00L) or “Aerosols I” (402-0572-00L)
- atmospheric physics: “Atmospheric Physics” (701-0475-00L)
- climate physics: “Klimasysteme” (701-0412-00L) or equivalent
- land-climate dynamics: “Land-climate dynamics” (701-1251-00L)
- climate modeling: “Numerical modeling of weather and climate” (701-1216-00L) (parallel attendance possible)
- atmospheric circulation: “Dynamics of large-scale atmospheric flow” (701-1221-00L)
- paleoclimate: “Climate History and Paleoclimate” (651-4057-00L)
- ocean biogeochemical dynamics: “Global Biogeochemical Cycles and Climate” (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.
- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric circulation (Prof. S. Schemm)
- paleoclimate (Prof. H. Stoll)
- ocean biogeochemical dynamics (Prof. N. Gruber)

Climate Processes and Feedbacks

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-1221-00L</td>
<td>Dynamics of Large-Scale Atmospheric Flow</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>H. Wernli, L. Papritz</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture course is about the fundamental aspects of the dynamics of extratropical weather systems (quasi-geostrophic dynamics, potential vorticity, Rossby waves, baroclinic instability). The fundamental concepts are formally introduced, quantitatively applied and illustrated with examples from the real atmosphere. Exercises (qualitative and qualitative) form an essential part of the course.</td>
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<tr>
<td>Objective</td>
<td>Understanding of dynamic processes of large-scale atmospheric flow and their mathematical-physical formulation.</td>
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<tr>
<td>Content</td>
<td>Dynamical Meteorology is concerned with the dynamical processes of the earth's atmosphere. The fundamental equations of motion in the atmosphere will be discussed along with the dynamics and interactions of synoptic system - i.e. the low and high pressure systems that determine our weather. The motion of such systems can be understood in terms of quasi-geostrophic theory. The lecture course provides a derivation of the mathematical basis along with some interpretations and applications of the concept.</td>
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<tr>
<td>Lecture notes</td>
<td>Dynamics of large-scale atmospheric flow</td>
<td></td>
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</tbody>
</table>
- Pichler H., Dynamik der Atmosphäre, Bibliographisches Institut, 456 pp. 1997 |
| Prerequisites / notice | Physics I, II, Environmental Fluid Dynamics |

<table>
<thead>
<tr>
<th>Number</th>
<th>European Climate Change</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>C. Schär, J. Rajczak, S. C. Scherr</th>
</tr>
</thead>
</table>
| Abstract   | The lecture provides an overview of climate change in Europe, from a physical and atmospheric science perspective. It covers the following topics:  
- observational datasets, observation and detection of climate change;  
- underlying physical processes and feedbacks;  
- numerical and statistical approaches;  
- currently available projections.  
At the end of this course, participants should:  
- understand the key physical processes shaping climate change in Europe;  
- know about the methodologies used in climate change studies, encompassing observational, numerical, as well as statistical approaches;  
- be familiar with relevant observational and modeling data sets;  
- be able to tackle simple climate change questions using available data sets. |
| Content    | Contents:  
- global context  
- observational data sets, analysis of climate trends and climate variability in Europe  
- global and regional climate modeling  
- statistical downscaling  
- key aspects of European climate change: intensification of the water cycle, Polar and Mediterranean amplification, changes in extreme events, changes in hydrology and snow cover, topographic effects  
- projections of European and Alpine climate change |
| Lecture notes | Slides and lecture notes will be made available at http://www.iac.ethz.ch/edu/courses/master/electives/european-climate-change.html |
| Prerequisites / notice | Participants should have a background in natural sciences, and have attended introductory lectures in atmospheric sciences or meteorology. |

<table>
<thead>
<tr>
<th>Number</th>
<th>Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS)</th>
<th>W</th>
<th>3 credits</th>
<th>6A</th>
<th>Supervisors</th>
</tr>
</thead>
</table>
| Abstract   | This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:  
- atmospheric chemistry  
- atmospheric dynamics  
- atmospheric physics  
- climate modeling  
- climate physics  
- land-climate dynamics  
- atmospheric circulation  
- paleoclimate  
- ocean biogeochemical dynamics |

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2243 of 2416
The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

The course has the following elements:

Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
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Weeks 6 and 9: Meetings with supervisor to clarify scientific questions
Week 12: Hand-in of written summary (4 pages maximum)
Week 14: Supervisor provides written feedback to the summary document
Week 16: Oral exam about the scientific topic

Climate History and Paleoclimatology explores how the major features of the earth's climate system have varied in the past, and the driving forces and feedbacks for these changes. The major topics include the earth's CO2 concentration and mean temperature, the size and stability of ice sheets and sea level, the amount and distribution of precipitation, and the ocean heat transport.

The student will be able to describe the natural factors leading to variations in the earth's mean temperature, the growth and retreat of ice sheets, and variations in ocean and atmospheric circulation patterns, including feedback processes. Students will be able to interpret evidence of past climate changes from the main climate indicators or proxies recovered in geological records. Students will be able to use data from climate proxies to test if a given hypothesized mechanism for the climate change is supported or refuted. Students will be able to compare the magnitudes and rates of past changes in the carbon cycle, ice sheets, hydrological cycle, and ocean circulation, with predictions for climate changes over the next century to millennia.

The lecture takes place if a minimum of 7 students register for it. Priority is given to PhD students majoring in Atmospheric and Climate Sciences, and remaining open spaces will be offered to the following groups:

- PhD student Environmental sciences
- MSc in Atmospheric and climate science
- MSc in Environmental sciences

### Atmospheric Composition and Cycles

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1235-00L</td>
<td>Cloud Microphysics</td>
<td>W</td>
<td>4 credits</td>
<td>2V+1U</td>
<td>Z. A. Kanji, N. Shardt, Y. Wang</td>
</tr>
</tbody>
</table>

Number of participants limited to 20. The lecture takes place if a minimum of 7 students register for it.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2244 of 2416
Clouds are a fascinating atmospheric phenomenon central to the hydrological cycle and the Earth’s climate. Interactions between cloud particles can result in precipitation, glaciation or evaporation of the cloud depending on its microstructure and microphysical processes.

The learning objective of this course is that students understand the formation of clouds and precipitation and can apply learned principles to interpret atmospheric observations of clouds and precipitation.

This course will be designed as a reading course in 1-2 small groups of 10 students maximum. It will be based on the textbook below. The students are expected to read chapters of this textbook prior to the class so that open issues, fascinating and/or difficult aspects can be discussed in depth.

Lamb and Verlinde: PHYSICS AND CHEMISTRY OF CLOUDS, Cambridge University Press, 2011

Target group: Doctoral and Master students in Atmosphere and Climate

<table>
<thead>
<tr>
<th>Prerequisites / notice</th>
<th>Self-directed learning on Advanced Topics in Atmospheric and Climate Science (HS)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Please contact one of the professors listed under prerequisites/notice if you plan to take this course.</td>
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<tr>
<td></td>
<td>Students are allowed to enroll in both courses 701-1280-00L &amp; 701-1281-00L Self-learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.</td>
</tr>
<tr>
<td>Abstract</td>
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<tr>
<td>Objective</td>
<td>The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).</td>
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<td>Content</td>
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<td></td>
<td>• ocean biogeochemical dynamics: “Global Biogeochemical Cycles and Climate” (701-1317-00L)</td>
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<tr>
<td></td>
<td>• ocean biogeochemical dynamics (Prof. N. Gruber)</td>
</tr>
</tbody>
</table>
Abstract

The lecture provides in the first part an introduction to the formation of air pollutants by technical processes, the emission of these chemicals into the atmosphere and their impact on air quality. The second part covers different strategies and techniques for emission reduction. The basic knowledge is deepened by the discussion of specific air pollution problems of today's society.

Objective

The students gain general knowledge of the technical processes resulting in air pollution and study the methods used for air pollution control. The students can identify major air pollution sources and understand the methods for measuring pollutants, collecting and analyzing data. The students can suggest and evaluate possible control methods and equipment, design control systems and estimate their efficiency and efforts.

The students know the different strategies of air pollution control and are familiar with their scientific fundamentals. They are able to incorporate goals concerning air quality into their engineering work.

Content

Part 1 Emission, Immission, Transmission

- Fluxes of pollutants and their environmental impact:
  - physical and chemical processes leading to emission of pollutants
  - mass and energy of processes
- Emission measurement techniques and concepts
- quantification of emissions from individual and aggregated sources
- extent and development of the emissions (Switzerland and global)
- propagation and transport of pollutants (transmission)
- meteorological parameters influencing air pollution dispersion
- deterministic and stochastic models, describing air pollution dispersion
- dispersion models (Gaussian model, box model, receptor model)
- measurement concepts for ambient air (immission level)
- extent and development of ambient air mixing ratios
- goal and instrument of air pollution control

Part 2 Air Pollution Control Technologies

The reduction of the formation of pollutants is done by modifying the processes (process-integrated measures) and by different engineering operations for the cleaning of waste gas (downstream pollution control). It will be demonstrated, that the variety of these procedures can be traced back to the application of a few basic physical and chemical principles.

Procedures for the removal of particles (inertial separator, filtration, electrostatic precipitators, scrubbers) with their different mechanisms (field forces, impaction and diffusion processes) and the modelling of these mechanisms.

Procedures for the removal of gaseous pollutants and the description of the driving forces involved, as well as the equilibrium and the kinetics of the relevant processes (absorption, adsorption as well as thermal, catalytic and biological conversions).

Discussion of the technical possibilities to solve the actual air pollution problems.

Lecture notes

Brigitte Buchmann, Air pollution control, Part I
Jing Wang, Air pollution control, Part II
Lecture slides and exercises

Literature

List of literature included in script

Language of instruction: In German or in English.

Prerequisites / notice

College lectures on basic physics, chemistry and mathematics.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
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<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td></td>
<td>Problem-solving</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Project Management</td>
<td>not assessed</td>
</tr>
<tr>
<td>Social Competencies</td>
<td>Communication</td>
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</tr>
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<td></td>
<td>Cooperation and Teamwork</td>
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<tr>
<td></td>
<td>Customer Orientation</td>
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</tr>
<tr>
<td></td>
<td>Leadership and Responsibility</td>
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<tr>
<td></td>
<td>Self-presentation and Social Influence</td>
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<td>Critical Thinking</td>
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<td></td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Self-direction and Self-management</td>
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651-4053-05L Boundary Layer Meteorology

Abstract

The Planetary Boundary Layer (PBL) constitutes the interface between the atmosphere and the Earth's surface. Theory on transport processes in the PBL and their dynamics is provided. The course starts by providing the theoretical background and reviewing idealized concepts. These are contrasted to real world applications and discussed in the context of current research issues.

Objective

Overall goals of this course are given below. Focus is on the theoretical background and idealized concepts. Students have basic knowledge on atmospheric turbulence and theoretical as well as practical approaches to treat Planetary Boundary Layer flows. They are familiar with the relevant processes (turbulent transport, forcing) within, and typical states of the Planetary Boundary Layer. Idealized concepts are known as well as their adaptations under real surface conditions (as for example over complex topography).

Content

- Introduction
- Turbulence
- Statistical treatment of turbulence, turbulent transport
- Conservation equations in a turbulent flow
- Closure problem and closure assumptions
- Scaling and similarity theory
- Spectral characteristics
- Concepts for non-ideal boundary layer conditions

Lecture notes

available (i.e. in English)
Sediments preserved a record of past landscapes. This course focuses on understanding the processes that modify sedimentary

The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic, 2) train self-study competences

The students learn basic concepts of modern sedimentology and stratigraphy in the context of sequence stratigraphy and sea level change.

2G

V. Picotti

This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:

- atmospheric chemistry
- atmospheric dynamics
- atmospheric physics
- climate modeling
- climate physics
- land-climate dynamics
- atmospheric circulation
- paleoclimate
- ocean biogeochemical dynamics

The grading of students is based on in-class exercises and end-semester examination.

Cambridge University Press

Angela Coe, the Open University.

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- ocean biogeochemical dynamics (Prof. N. Gruber)

If you plan to take this course, please contact one of the professors according to your interest.

- atmospheric chemistry (Prof. T. Peter)
- atmospheric dynamics (Prof. H. Wernli)
- atmospheric physics (Prof. U. Lohmann)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- atmospheric chemistry (Prof. T. Peter)
- climate modeling (Prof. C. Schär)
- climate physics (Prof. R. Knutti)
- land-climate dynamics (Prof. S. Seneviratne)
- ocean biogeochemical dynamics (Prof. N. Gruber)

The grading of students is based on in-class exercises and end-semester examination.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2247 of 2416
Abstract
The course will focus on biological and chemical aspects of sedimentation in marine environments. Marine sedimentation will be traced from coast to deep-sea. The use of stable isotopes palaeoceanography will be discussed. Neritic, hemipelagic and pelagic sediments will be used as proxies for environmental change during times of major perturbations of climate and oceanography.

Objective
- You will understand chemistry and biology of the marine carbonate system
- You will be able to relate carbonate mineralogy with facies and environmental conditions
- You will be familiar with cool-water and warm-water carbonates
- You will see carbonate and organic-carbon rich sediments as part of the global carbon cycle
- You will be able to recognize links between climate and marine carbonate systems (e.g. acidification of oceans and reef growth)
- You will be able to use geological archives as source of information on global change
- You will have an overview of marine sedimentation through time

Content
- carbonates, chemistry, mineralogy, biology
- carbonate sedimentation from the shelf to the deep sea
- carbonate facies
- cool-water and warm-water carbonates
- organic-carbon and black shales
- C-cycle, carbonates, CO2 sources and sink
- Carbonates: their geochemical proxies for environmental change: stable isotopes, Mg/Ca, Sr
- marine sediments through geological time
- carbonates and evaporites
- lacustrine carbonates
- economic aspects of limestone

Lecture notes
No script. Scientific articles will be distributed during the course.

Literature
We will read and critically discuss scientific articles relevant for "biological and chemical processes in marine and lacustrine systems".

Prerequisites / notice
The grading of students is based on in-class exercises and end-semester examination.
Content

Week 1 (September 21): Introduction, content, structure of the course, objectives, bibliography, grading and evaluation; soil texture, particle size distribution, soil structure, soil surface area, porosity and bulk density.

Week 2 (September 28): Pore scale consideration, pore sizes, shapes and connectivity; coordination number, continuity and percolation; surface tension; Young-Laplace equation; capillary rise; contact angle.

Week 3 (October 05): Friction and laminar flow; Hagen-Poiseuille’s law; Washburn equation; numerical lab (including report)

Week 4 (October 12): Soil water content; soil water potential - The energy state of soil water; total water potential and its components; volumetric and gravimetric water contents; field capacity and wilting point.

Week 5 (October 19): Soil water characteristics - definitions and measurements; parametric models, fitting and interpretation, hysteresis; Demo lab (including report)

Week 6 (October 26): Saturated water flow in soils - Laminar flow in tubes (Poiseuille’s Law); Darcy’s Law, conditions and states of flow; permeability and hydraulic conductivity, measurement and theoretical concepts (Kozeny-Carman); effective conductivity; unsaturated hydraulic conductivity; Buckingham law.

Week 7 (November 02): Unsaturated water flow in soils - Unsaturated hydraulic conductivity models and applications; Richards equation, approximations of Richards equation for steady state; approximate solutions to infiltration (Green-Ampt, Philip); outlook on unstable and preferential flow

Week 8 (November 09): Numerical solution of Richards equation – Using Hydrus1D for simulation of unsaturated flow; choosing class project (including report)

Week 9 (November 16): Solute and gas transport in soils - Transport mechanisms of solutes in porous media; breakthrough curves; convection-dispersion equation; solutions for pulse and step solute application; parameter estimation; salt balance.

Week 10 (November 23): Conductivity and resistance of soils – differences and similarities of hydraulic, electrical, thermal conductivities; Buckingham-Darcy, Fourier, and Archie’s law; pore scale characteristics and effective conductivities; soil thermal properties; steady state and non-steady heat flow

Week 11 (November 30): Energy balance and land atmosphere interactions - Radiation and energy balance; evapotranspiration, potential and actual evaporation, definitions and estimation; evaporation stages and characteristic length

Week 12 (December 07): Root water uptake and transpiration – Mechanisms controlling root water uptake; hydraulic properties of rhizosphere; plant and stomatal conductance

Week 13 (December 14): Summary, questions, old exam

Week 14 (December 21): Written Semester-end exam

Literature

Supplemental textbook (not mandatory) - Introduction to Environmental Soil Physics, by: D. Hillel

701-1281-00L Self-Learning Course on Advanced Topics in Atmospheric and Climate Science (HS)

W 3 credits 6A

Supervisors

Please contact one of the professors listed under prerequisites/notice if you plan to take this course.

Students are allowed to enroll in both courses 701-1280-00L & 701-1281-00L Self-learning Course on Advanced Topics in Atmospheric and Climate Science but have to choose different supervisors.

Abstract

This course offers an individual pathway to deepen knowledge and understanding of a specific advanced topic in atmospheric and climate science in one of these fields:
- atmospheric chemistry
- atmospheric dynamics
- atmospheric physics
- climate modeling
- climate physics
- land-climate dynamics
- atmospheric circulation
- paleoclimate
- ocean biogeochemical dynamics

Objective

The learning goals of this course are threefold: 1) obtain novel insight into an advanced scientific topic; 2) train the self-study competences in particular related to reading of advanced textbooks and writing a concise summary, and 3) gain experience in the scientific interaction with experts. The format of the course is complementary to other types of teaching (lectures and seminars) and addresses skills that are essential for a wide range of professional activities (including a PhD).

Content

The course has the following elements:

Week 1: Selection of specific topic and decision about reading material (textbook chapters and maybe 1-2 review papers)
Week 2: General discussion about self-study skills (how to read scientific literature and write summaries; specifics of scientific writing; how to prepare efficient meetings). For the scientific writing, students are encouraged to participate in an online training course offered by Stanford University: https://www.coursera.org/learn/sciwrite?action=enroll
Weeks 6 and 9: Meetings with supervisor to clarify scientific questions
Week 12: Hand-in of written summary (4 pages maximum)
Week 14: Supervisor provides written feedback to the summary document
Week 16: Oral exam about the scientific topic

Literature

Literature (including book chapters, scientific publications) will be provided by the responsible supervisor in coordination with the student.
Groundwater - 1S

J. W. Kirchner, University lecturers

The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from:

- Introduction to groundwater problems. Concepts to quantify properties of aquifers.
- Atmospheric physics: "Atmospheric Physics" (701-0475-00L)
- Climate physics: "Klimasysteme" (701-0412-00L) or equivalent
- Land-climate dynamics: "Land-climate dynamics" (701-1251-00L)
- Climate modeling: "Numerical modeling of weather and climate" (701-1216-00L) (parallel attendance possible)
- Atmospheric circulation: "Dynamics of large-scale atmospheric flow" (701-1221-00L)
- Paleoclimates: "Climate History and Paleoclimates" (651-4057-00L)
- Ocean biogeochemical dynamics: "Global Biogeochemical Cycles and Climate" (701-1317-00L)

If you plan to take this course, please contact one of the professors according to your interest.

- Atmospheric chemistry (Prof. T. Peter)
- Atmospheric dynamics (Prof. H. Wernli)
- Atmospheric physics (Prof. U. Lohmann)
- Climate modeling (Prof. C. Schär)
- Climate physics (Prof. R. Knutti)
- Land-climate dynamics (Prof. S. Seneviratne)
- Atmospheric circulation (Prof. S. Schemm)
- Paleoclimates (Prof. H. Stoll)
- Ocean biogeochemical dynamics (Prof. N. Gruber)

**102-0287-00L River Basin Erosion**

**W 3 credits 2G P. Molnar**

**Abstract**

The course presents a view of the catchment processes of sediment production and transport that shape the landscape. Focus is on sediment fluxes from sources on hillslopes to the river network. Students learn about how a fluvial system functions, how to identify sediment sources and sinks, how to make predictions with numerical models, develop sediment budgets, and quantify geomorphic change.

**Objective**

The course has two fundamental aims: (1) The first aim is to provide environmental engineers with the physical process basis needed to understand fluvial system change, using the right language and terminology to describe landforms. We will cover the main geomorphic concepts of landscape change, e.g. thresholds, equilibrium, criticality, to describe change. Students will learn about the importance of the concepts of connectivity and timescales of change. (2) The second aim is to provide quantitative skills in making simple and more complex predictions of change and the data and models required. We will learn about typical landscape evolution models, and about hillslope erosion model concepts like RUSLE. We will learn how to identify sediment sources and sinks, and develop simple sediment budgets with the right data needed for this purpose. Finally we will learn about methods to describe the topology of river networks as conduits of sediment transport through the fluvial system.

**Content**

The course consists of four sections: (1) Introduction to fluvial forms and processes and geomorphic concepts of landscape change, including climatic and human activities acting on the system. Concepts like thresholds, equilibrium, self-organised criticality, etc. are presented. (2) Landscape evolution modelling as a tool for describing the shape of the land surface. Soil formation and sediment production at long timescales. (3) The processes of sediment production, upland sheet- and rill-gully erosion, basin sediment yield, rainfall-triggered landsliding, sediment budgets, and the modelling of the individual processes involved. Here we combine model concepts with field observations and look at many examples. (4) Processes in the river, floodplain and riparian zone, including river network topology, channel geometry, aquatic habitat, role of riparian vegetation, including basics of fluvial system management. The main focus of the course is on the hydrology-sediment connections at the field and catchment scale.

**Lecture notes**

There is no script.

**Literature**

The course materials consist of a series of 13 lecture presentations and notes to each lecture. The lectures were developed from textbooks, professional papers, and ongoing research activities of the instructor. All material is on the course webpage.

**Prerequisites / notice**

Prerequisites: Basic Hydrology and Watershed Modelling (or contact instructor).

**651-2915-00L Seminar in Hydrology**

**Z 0 credits 1S P. Burlando, J. W. Kirchner, C. Schär, M. Schirmer, S. I. Seneviratne, M. Stähli, C. H. Stamm, University lecturers**

**Abstract**

The course provides an introduction into quantitative analysis of groundwater flow and solute transport. It is focussed on understanding, formulating, and solving groundwater flow and solute transport problems.

**Objective**

a) Students understand the basic concepts of groundwater flow and solute transport processes, and boundary conditions.

b) Students are able to formulate simple, practical groundwater flow and solute transport problems.

c) Students are able to understand and apply simple analytical and/or numerical solutions to fluid flow and solute transport problems.

**Content**

1. Introduction to groundwater problems. Concepts to quantify properties of aquifers.

2. Flow equation. The generalised Darcy law.

3. The water balance equation and basic concepts of poroelasticity.


5. Analytical solutions to flow problems

6. Finite difference scheme solution for simple flow problems.


10. Analytical solutions to transport problems.

11. Fractured and karst aquifers.

12. The unsaturated zone and capillary pressure.

13. Examples of applied hydrogeology from Switzerland and around the world. (Given by Dr. Beatrice Marti from Hydrosolutions Ltd.)
Atmospheric Passive and Active Remote Sensing is connected with a large number of applications including: atmospheric composition.

ECTS Handouts of slides.

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Cooperation and Conflict Over International Water Resources

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

Abstract

This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Objective

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

20. Sep Global water challenges
27. Sep Nuts and bolts of hydrological modeling and what such models can tell us
04. Oct Nuts and bolts of hydrological modeling and what such models can tell us
11. Oct Water pollution and its mitigation
18. Oct Key challenges in international river systems
25. Oct Key challenges in international river systems
01. Nov Case study 1: Yarmuk
08. Nov Case study 2: Mekong
15. Nov Case study 3: Colorado
22. Nov Case study 4: Nile
29. Nov Case study 5: Central Asia
06. Dec Wrap up: what we can learn from these case studies
13. Dec Exam
20. Dec No class

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.

Additional Elective Courses

### Atmospheric Remote Sensing

### Abstract

The course will provide advanced physical understanding on the fundamentals of passive and active remote sensing, measuring sensors and retrieval methods. A series of diverse remote sensing applications will be presented, including measurements/retrievals of various atmospheric composition parameters (ozone, aerosols, clouds, others) from surface based and satellite based instruments.

### Objective

The students will learn how various components of the atmosphere are retrieved from radiation measurements, both from surface and satellite-based measurements.

### Content

Atmospheric passive and active remote sensing is connected with a large number of applications including: atmospheric composition, Earth-atmosphere radiative balance, atmospheric and weather prediction model assimilation, agriculture, energy and health related applications and many others.

The proposed lesson is divided in three sections including exercises:

- Fundamentals of remote sensing
- Sensors (surface based and satellites) and retrieval methods
- Applications

The first aim of the lecture is to provide an in-depth understand of the physical aspects and basic laws on the fundamentals of remote sensing to the students. The lectures will provide a basic to intermediate understanding of radiative transfer of electromagnetic radiation through the atmosphere, covering the spectrum from UV to thermal. Examples of atmospheric components that will be addressed are: ozone, aerosols, greenhouse gases, clouds, water vapor.

In addition, measuring sensors used from the surface or from satellites and the relevant retrieval methods based on passive and active remote sensing of atmospheric composition will be presented (e.g. Spectroradiometers, filter radiometers, Lidars and others).

Finally, we aim to demonstrate a series of diverse remote sensing applications, including atmospheric composition measurements and retrievals from surface- and satellite-based instruments, including calibration and validation aspects.

The exercises will be embedded in the overall course lectures to provide hands-on experience with the measurements and retrieval methods using datasets available from specific instruments (e.g. satellite sensors) and networks (e.g. EUBREWNET, AERONET, GAWPFR).
Lecture notes

Prerequisites / notice

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
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<tr>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Project Management</td>
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Social Competencies

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<tr>
<td>Negotiation</td>
<td>not assessed</td>
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</tbody>
</table>

Personal Competencies

| Adaptability and Flexibility | not assessed |
| Creative Thinking | not assessed |
| Critical Thinking | assessed |
| Integrity and Work Ethics | assessed |
| Self-awareness and Self-reflection | not assessed |
| Self-direction and Self-management | not assessed |

Number of participants limited to 30.

Enrollment starts on 19.09.2022

Waiting list will be deleted on 03.10.2022.

Abstract

The course will consist of overview lectures, hands-on practical exercises on (1) the basics of statistical learning and (2) with a focus on applications for atmospheric and climate science. Lectures will cover theoretical basics of statistical learning (advanced regression, nonlinear methods) and an overview of applications of statistical learning in the atmospheric and climate sciences.

Objective

- Understanding elements and principals of statistical learning
- Ability to select the appropriate statistical learning tools to tackle atmospheric and climate research problems
- Ability to apply methods of statistical learning to atmospheric and climate research

Content

- Data in atmospheric and climate research (data types, observations, models)
- Exploring properties of atmospheric and climate data (data in space and time, multivariate data)
- Concepts of supervised learning (bias variance trade-off, overfitting, cross-validation)
- Advanced linear regression (multiple linear regression, regularization)
- Non-linear regression (tree based methods, neural networks)
- Un-supervised learning (dimension reduction, clustering)
- High-level applications of statistical learning for atmospheric and climate research (keynote speakers)

Literature


Prerequisites / notice

- Knowledge of introductory statistics
- Overview on the climate system
- Basic experience in a programming language

Course should be limited to 30 participants.

Exercises will be conducted in the R environment (https://www.r-project.org/), which is a specialized tool for statistical computing.

701-3001-00L

Environmental Systems Data Science: Data Processing

Number of participants limited to 80.

Course registration starts on 31.08.2022.

Waiting list will be deleted on 30.09.2022.

Abstract

Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.
The students are able to
● frame a data science problem and build a hypothesis
● describe the steps of a typical data science project workflow
● conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate
algorithms and models
● critically think about the limits and implications of a method
● visualise data and results throughout the workflow
● access online resources to keep up with the latest data science methodology and deepen their understanding

Content
● The data science workflow
● Access and handle (large) datasets
● Prepare and clean data
● Analysis: data exploratory steps
● Analysis: machine learning and computational methods
● Evaluate results and analyse uncertainty
● Visualisation and communication

Prerequisites / notice
252-0840-02L Anwendungsnahe Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt- und Naturswissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning
Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022.

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning models.

Objective
The students are able to
● select an appropriate model related to a research question and dataset
● describe the steps from data preparation to running and evaluating models
● prepare data for running machine learning with dependent and independent variable
● build and validate regressions and neural network models
● understand convolution and deep learning models
● access online resources to keep up with the latest data science methodology and deepen their understanding

Content
● The data science workflow
● Data preparation for running and validating machine learning models
● Get to know machine learning approaches including regression, random forest and neural network
● Model complexity and hyperparameters
● Model parameterization and loss
● Model evaluations and uncertainty
● Deep learning with convolutions

Literature
Building on existing data science resources

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

651-4273-00L Numerical Modelling in Fortran

W 3 credits 2G L. Pellissier, E. J. Harris, J. Payne, M. Volpi

Abstract
This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

Objective
Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

Lecture notes
See http://jupiter.ethz.ch/~pjt/FORTRAN/FortranClass.html

Fostered competencies
Subject-specific Competencies
Techniques and Technologies
Medial and Digital Technologies
Problem-solving
assessed
assessed
assessed

651-4273-01L Numerical Modelling in Fortran (Project)
Prerequisite: 651-4273-00L Numerical Modelling in Fortran

W 1 credit 1U P. Tackley

Abstract
This course gives an introduction to programming in Fortran, and is suitable for students who have only minimal programming experience. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts.

Objective
Fortran is a modern programming language that is updated every few years (most recently in 2018) and is specifically designed for scientific and engineering applications. This course gives an introduction to programming in this language, and is suitable for students who have only minimal programming experience, for example with MATLAB scripts. The focus will be on Fortran 95-2018, but differences to Fortran 77 will be mentioned for those working with already-existing codes. A hands-on approach will be emphasized rather than abstract concepts, using example scientific problems relevant to Earth science.

Content
The project consists of writing a Fortran program to solve a problem agreed upon between the instructor and student; the topic is often related to (and helps to advance) the student's Masters or PhD research. The project is typically started towards the end of the main Fortran class when the student has acquired sufficient programming skills, and is due by the end of Semesterprüfung week.

Lecture notes
See http://jupiter.ethz.ch/~pjt/FORTRAN/FortranProject.html
The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and decay modes of relevant radiogenic isotopes. They discover the spectrum of possible geochemical tracers and biomarkers, their potential and limitations and get familiar with important applications.

Isotopes and Biomarkers in Biogeochemistry

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>701-1313-00L</td>
<td>Isotopes and Biomarkers in Biogeochemistry</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>C. Schubert, N. Casacuberta Arola, R. Kipfer</td>
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</tbody>
</table>

Abstract: The course introduces the scientific concepts and typical applications of tracers in biogeochemistry. The course covers stable and radioactive isotopes, geochemical tracers and biomarkers and their application in biogeochemical processes as well as regional and global cycles. The course provides essential theoretical background for the lab course "Isotopic and Organic Tracers Laboratory".

Objective: The course aims at understanding the fractionation of stable isotopes in biogeochemical processes. Students learn to know the origin and decay modes of relevant radiogenic isotopes. They discover the spectrum of possible geochemical tracers and biomarkers, their potential and limitations and get familiar with important applications.

Content: Geogenic and cosmogenic radionuclides (sources, decay chains); stable isotopes in biogeochemistry (natural abundance, fractionation); geochemical tracers for processes such as erosion, productivity, redox fronts; biomarkers for specific microbial processes.

Lecture notes: handouts will be provided for every chapter

Literature: A list of relevant books and papers will be provided

Prerequisites / notice: Students should have a basic knowledge of biogeochemical processes (BSc course on Biogeochemical processes in aquatic systems or equivalent)

Biogeochemistry of Trace Elements

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1315-00L</td>
<td>Biogeochemistry of Trace Elements</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>A. Voegelin, S. Bouchet, L. Winkel</td>
</tr>
</tbody>
</table>

Abstract: The course addresses the biogeochemical classification and behavior of trace elements, including key processes driving the cycling of important trace elements in aquatic and terrestrial environments and the coupling of abiotic and biotic transformation processes of trace elements. Examples of the role of trace elements in natural or engineered systems will be presented and discussed in the course.

Objective: The students are familiar with the chemical characteristics, the environmental behavior and fate, and the biogeochemical reactivity of different groups of trace elements. They are able to apply their knowledge on the interaction of trace elements with geosphere components and on abiotic and biotic transformation processes of trace elements to discuss and evaluate the behavior and impact of trace elements in aquatic and terrestrial systems.

Content: (i) Definition, importance and biogeochemical classification of trace elements. (ii) Key biogeochemical processes controlling the cycling of different trace elements (base metals, redox-sensitive and chalcophile elements, volatile trace elements) in natural and engineered environments. (iii) Abiotic and biotic processes that determine the environmental fate and impact of selected trace elements.

Lecture notes: Selected handouts (lecture notes, literature, exercises) will be distributed during the course.

Prerequisites / notice: Students are expected to be familiar with the basic concepts of aquatic and soil chemistry covered in the respective classes at the bachelor level (soil mineralogy, soil organic matter, acid-base and redox reactions, complexation and sorption reactions, precipitation/dissolution reactions, thermodynamics, kinetics, carbonate buffer system).

The lecture 701-1315-00L Biogeochemistry of Trace Elements is a prerequisite for attending the laboratory course 701-1331-00L Trace Elements Laboratory, or students must be concurrently enrolled in 701-1315-00L Biogeochemistry of Trace Elements in the same semester.

Physical Transport Processes in the Natural Environment

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1316-00L</td>
<td>Physical Transport Processes in the Natural Environment</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>J. W. Kirchner</td>
</tr>
</tbody>
</table>

Abstract: Fluid flows transport all manner of biologically important gases, nutrients, toxins, contaminants, spores and seeds, as well as a wide range of organisms themselves. This course explores the physics of fluids in the natural environment, with emphasis on the transport, dispersion, and mixing of solutes and entrained particles, and their implications for biological and biogeochemical processes.

Objective: Students will learn key concepts of fluid mechanics and how to apply them to environmental problems. Weekly exercises based on real-world data will develop core skills in analysis, interpretation, and problem-solving.

Content: dimensional analysis, similarity, and scaling transport in laminar and turbulent flows transport and dispersion in porous media transport of sediment (and adsorbed contaminants) by air and water anomalous dispersion

Lecture notes: The course is under development. Lecture materials will be distributed as they become available.

Carbon Mitigation

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1346-00L</td>
<td>Carbon Mitigation</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>N. Gruber</td>
</tr>
</tbody>
</table>

Priority is given to the target groups: Bachelor and Master Environmental Sciences and PHD Environmental Sciences until 20.09.2022. Waiting list will be deleted 30.09.2022.

Abstract: Future climate change can only be kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

Objective: The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

Content: From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

Lecture notes: None

Literature: Will be identified based on the chosen topic.

Prerequisites / notice: Exam: No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

Anthropogenic Particles in the Environment

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1351-00L</td>
<td>Anthropogenic Particles in the Environment</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>B. Nowack, T. Bucheli, D. Mitrano</td>
</tr>
</tbody>
</table>

The lecture provides an overview on the behavior and effects of anthropogenic particles in the environment, covering engineered nanoparticles, micro/nanoplastics, tire wear, soot and pigments. The course will cover key concepts of particle behavior and analysis, fate in technical and natural systems, toxicity and environmental risk assessment and sustainability aspects and regulation.
Objective
- Successful application of knowledge gained in traditional disciplines of environmental sciences (e.g., biogeochemistry, environmental chemistry) to elucidate particle fate and behavior in the environment
- Identify key parameters that potentially influence the environmental fate and behavior of anthropogenic particles
- Get acquainted with the most common analytical tools for the quantification of anthropogenic particles in the environment
- Critical assessment of current state of research, including the sometimes controversial literature data

Content
- Definitions, particle types
- Particle behavior: colloidal behavior, transport, transformation
- Sources and release: Material flow modeling
- Fundamentals of particle analysis
- Release and emission
- Fate in the environment: water, soil, air
- Fate in technical systems: water treatment, waste incineration
- Uptake and toxicity of particles
- Environmental risk assessment
- Life cycle assessment

Lecture notes
Handouts will be provided

Literature

860-0012-00L  Cooperation and Conflict Over International Water Resources  W  3 credits  2G  T. Bernauer, T. U. Siegfried

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

Abstract
This course focuses on the technical, economic, and political challenges of dealing with water allocation and pollution problems in large international river systems. It examines ways and means through which such challenges are or can be addressed, and when and why international efforts in this respect succeed or fail.

Objective
Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content
The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

Methods and Tools: Lab Courses

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1331-00L</td>
<td>Biogeochemistry of Trace Elements Laboratory  ■</td>
<td>W</td>
<td>3</td>
<td>4P</td>
<td>L. K. Thomas Arrigo, K. Barmettler</td>
</tr>
</tbody>
</table>

Number of participants limited to 40. Priority for Science, Technology, and Policy MSc.

Abstract
The course offers a practical introduction into the investigation of the biogeochemistry of trace elements. Laboratory experiments are performed to study a selected environmental process. Advanced techniques for the analysis of total element contents and element speciation are used. The experimental findings are interpreted and discussed in their environmental context.

Objective
The objective of this course, is to offer students a practical introduction into the investigation of the biogeochemistry of trace elements. During the course, students will become familiar with some of the key experimental approaches typically used in the investigation of the biogeochemistry of trace elements in the laboratory. In addition, students will learn to use different advanced analytical techniques to measure the total content and the speciation of trace elements in both liquid and solid samples. The students will interpret and discuss their experimental findings in the context of the studied environmental system.

Content
Laboratory experiments are designed and performed to study the interplay of various biogeochemical processes in a specific environmental system. Moreover, the effect of these processes on the biogeochemical cycling of trace elements in the environment will be considered. Advanced techniques for the analysis of total element contents and element speciation are used. The experimental findings are interpreted and discussed in the context of the the environmental system under investigation.

Lecture notes
Selected handouts will be distributed during the course.
1. Introduction to the ecological functions of Swiss forest soils

Selected publications will be distributed during the course.

P. U. Lehmann Grunder


A manual will be distributed during the course.

4G

All necessary literature will be uploaded to the ILIAS repository during the course.

The main part of the course is the investigation of real samples of soils/sediments in the lab working in groups. A brief theoretical introduction to mineralogy and texture of soils will be given.

M. Plötze

The students are measuring carbon and nutrient fluxes in forest soils under a changing climate and land-use. In laboratory and field experiments, they are manipulating climatic conditions (temperature, drought) and quantify the response of C and N fluxes in soils, and plant-soil interactions. The results will be interpreted and discussed in the context of changes in climate and land-use.

F. Hagedorn

Basic introduction to mineralogy and texture of soils

Students know how to use tracers/isotopes to investigate/understand ecosystems

C. Schubert

Upon successful completion of this course students are able to:

- measure and describe structural, mineralogical and chemical properties of the inorganic solid part of soils and sediments,
- propose and apply different advanced methods and techniques to measure these properties,
- critically assess the data and explain the relationships between them,
- communicate the results in a scientific lab report.

Duebendorf, and 2 days of preparation of a presentation and the presentation itself at ETH (Center). The presentation will be evaluated and is necessary to pass the class.

Prerequisites / notice

Sampling will take place in Rotsee (Lucerne). We will have 3 laboratory days at Eawag Kastanienbaum, 1 laboratory day at Eawag Duebendorf, and 2 days of preparation of a presentation and the presentation itself at ETH (Center). The presentation will be evaluated and is necessary to pass the class.

701-1337-00L Forest Soils in a Changing Environment

W 3 credits

F. Hagedorn, P. F. Schleppi

Abstract

The students are measuring carbon and nutrient fluxes in forest soils under a changing climate and land-use. In laboratory and field experiments, they are manipulating climatic conditions (temperature, drought) and quantify the response of C and N fluxes in soils, and plant-soil interactions. The results will be interpreted and discussed in the context of changes in climate and land-use.

Objective

The students get first-hand experience with field and laboratory methods to measure carbon and nutrient fluxes and the application of stable isotope techniques. They shall learn about physico-chemical properties of Swiss forest soils, how these properties determine the ecological functions of soils and how soils respond to changes in climate and land-use. Finally the students shall interpret, discuss and present their experimental data.

Content

1. Introduction to the ecological functions of Swiss forest soils
2. Measurement of soil CO2 efflux, carbon and nutrient leaching in forest and grassland soils
3. Sampling and preparation of litter and soil samples from selected soil profiles under different land-use conditions
4. Setting-up laboratory experiments in microcosms. Measurement of soil respiration and leaching of carbon, nutrients and/or contaminants in climate chambers under different environmental conditions.
5. Analyses of litter, soil, and soil water for selected physical and chemical properties.
7. Interpretation and final presentation of data

Lecture notes

A manual will be distributed during the course.

Literature

Selected publications will be distributed during the course.

701-1339-00L Soil Solids Laboratory

W 3 credits

M. Plötze

Abstract

The main part of the course is the investigation of real samples of soils/sediments in the lab working in groups. A brief theoretical introduction into the overall principle and the meaning of physical, mineralogical and chemical parameters of soils and sediments and into each analytical method for their investigation will be given in advance.

Objective

Upon successful completion of this course students are able to:

- describe structural, mineralogical and chemical properties of the inorganic solid part of soils and sediments,
- propose and apply different advanced methods and techniques to measure these properties,
- critically assess the data and explain the relationships between them,
- communicate the results in a scientific lab report.

The competencies of process understanding, system understanding, concept development, and measurement methods are taught and assessed.

Content

Basic introduction to mineralogy and texture of soils

Analytical techniques

Practical exercises in sample preparation

Measurement and evaluation of the data:

- physical parameters (grain size distribution, surface, densities, porosity, (micro)structure)
- mineralogical/geochemical parameters (quantitative mineralogical composition, thermal analysis, cation exchange etc.)

Lecture notes

Selected handouts will be distributed during the course.

Literature


In order to allow for effective lab work not more than 12 students can join the course.

Prerequisites / notice

Useful preparatory courses are: "Soil Chemistry", "Clays in Geotechnics", and "X-ray powder diffraction".

701-1673-00L Environmental Measurement Laboratory

W 5 credits

P. U. Lehmann Grunder,
A. Carminati

Number of participants limited to 24.

Waiting list will be deleted 23.09.2022.
The students will be able to:
- explain measurement principles that are used for characterization of landscapes and terrestrial systems
- select appropriate measurement methods and sampling design to quantify key variables and processes above ground and in the subsurface
- deploy sensors in the field
- interpret collected laboratory and field data and report main conclusions deduced from measurements

Week 1: Plant-Soil interactions – short introduction before sensor demonstration and installation in forest lab; Scholander pressure bomb (suction in leaves); LICOR soil chamber

Week 2: Lecture on Measurement Science, overview of water content and water potential sensors; data logging and data logger programming; tests in the lab

Week 3: Introduction on soil physics; Field installation of sensors and field experiment; data collection for a few days; solar panel

Week 4: Soil sampling in field lab including geoprobe measurements

Week 5: Introduction on forest lab - Soil sampling in forest lab; root length density;

Week 6: Lecture on geophysical methods on Subsurface Characterization: Basic principles of ERT, GPR, and EM; simple lab tests on effective resistivity

Week 7: Demonstration and application of geophysical methods in the field

Week 8: Lecture on plant soil relationship: connecting information below and above ground – data analysis

Weeks 9 and 10: Forest characterization/ inventory: Principles of LiDAR; structures and features of the tree crowns, size/volume of the leaf area tree positions and diameters at breast height

Weeks 11 and 12: Eddy covariance methods -Principles for field measurement of water vapor, carbon dioxide, and energy exchange between terrestrial surfaces and the atmosphere; Analysis of measured time series to determine evaporation rate and CO2-fluxes

Week 13: Swiss Soil Monitoring networks – Monitoring of soil water content and potential; climate change and droughts

Week 14: Global data – Global modeling and data interpretation; SoilGrids and OpenLandMap; exercises on Budyko analysis

Lecture material will be online for registered students using moodle

The details of the schedule will be optimized based on the number of students; some blocks of the course will be offered as well to students of Environmental Engineering

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td></td>
<td>Prerequisite: Term Paper 1: Writing</td>
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<tr>
<td></td>
<td>701-1303-00L</td>
<td>Only for Environmental Sciences MSc and Science, Technology and Policy MSc.</td>
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</tbody>
</table>

Abstract

Critical Thinking

Measurement

Science and Technology

The ability to critically evaluate original (scientific) literature and to summarise the information in a succinct manner is an important skill for any student. This course aims to practice this ability, requiring each student to write a term paper of scientific quality on a topic of relevance for research in the areas of biogeochemistry and pollutant dynamics.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2257 of 2416
Objective
The goal of the term paper is to train the student's ability to critically evaluate scientific literature and to summarise the findings concisely in a paper addressing a research question.

At the end of the course, students will be able to:
- narrow down a research question.
- identify relevant literature to address the research question.
- concisely summarise and critically evaluate their findings.
- formulate key outstanding questions.

Content
Each student is expected to write a paper with a length of approximately 15-20 pages. The students can choose from a list of topics prepared by the tutors, but the final topic will be determined based on a balance of choice and availability. The students will be guided and advised by their tutors throughout the term.

The paper itself should contain the following elements:
- Motivation and context of the given topic (25%)
- Concise presentation and critical evaluation of the state of the science (50%)
- Identification of open questions and perhaps opportunities for further research (25%)

In addition, the accurate use of citations, attribution of ideas, and the judicious use of figures, tables, equations and references are critical components of a successful paper. Specialised knowledge is not expected, nor required; neither is new research.

Lecture notes
Guidelines and supplementary material are distributed on the Moodle platform.

Literature
Original scientific literature will be identified based on the chosen topic.

Prerequisites / notice
Please enrol latest until the first week of the semester. Contact termpaper(at)env.ethz.ch if you don't yet have access to MyStudies.

The term paper course is primarily aimed at master students majoring in biogeochemistry & pollutant dynamics and ISTP students with a solid background in natural sciences and a strong interest in biogeochemistry & pollutant dynamics.

Each student submits a term paper that will be reviewed by one fellow student and one faculty. The submission of the term paper and a written review of another student's term paper are a condition for obtaining the credit points.

There is no final exam. The grade is assigned based on the quality of the term paper and the submitted review as well as on the presentation in the following term.

Results from the term paper will be presented to fellow students and involved faculty in the following semester ("Term Paper 2: Seminar").

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies not assessed

Method-specific Competencies
Analytical Competencies assessed
Communication assessed

Social Competencies
Critical Thinking assessed
Self-direction and Self-management not assessed

Electives

Number Title Type ECTS Hours Lecturers
701-3001-00L Environmental Systems Data Science: Data Processing W 2 credits 2G L. Pellissier, E. J. Harris, J. Payne, M. Volpi

"Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar."

Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022,

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
252-0840-02L Anwendungsnahe Programmierung mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umweltfachwissenschaften
Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022.

**Target groups**
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

**Abstract**
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods.

**Objective**
The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

**Content**
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

**Literature**
Building on existing data science resources

**Prerequisites / notice**
Math IV, VI (Statistics); R, Python; ESDS I

### Major in Ecology and Evolution

#### A. Fundamentals

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0328-00L</td>
<td>Advanced Ecological Processes</td>
<td>W</td>
<td>4</td>
<td>2V</td>
<td>J. Hille Ris Lambers</td>
</tr>
</tbody>
</table>

**Abstract**
This course presents theoretical and empirical approaches to understanding the ecological processes structuring populations and communities. Central problems covered include species interactions, spatial structure, resource dynamics, and ecological responses to environmental change. These and other topics will be explored from basic and applied perspectives.

**Objective**
Students will understand how ecological processes operate in natural communities. They will appreciate how mathematical theory, field experimentation, and observational studies combine to generate a predictive science of ecological processes, and how this predictive science informs conservation and management decisions.

Upon completing the course, students will be able to:

- Understand the factors determining the outcome of species interactions in communities, and how this information informs management.
- Apply theoretical knowledge on species interactions to predict the potential outcomes of novel species introductions.
- Understanding the role of spatial structure in mediating population dynamics and persistence, species interactions, and patterns of species diversity.
- Use population and community models to predict the stability of interactions between predators and prey and between different competitors.
- Understand the conceptual basis of predictions concerning how ecological communities will respond to global change.
- Discuss the types of conceptual advances ecology as a science can realistically achieve, and how these relate to the applications of the discipline.

**Content**
Lectures supplemented with readings from the primary literature and occasional computer exercises will focus on understanding central processes in community ecology. Topics will include demographic and spatial structure, consumer resource interactions, food webs, competition, mutualism, invasion, the maintenance of species diversity, and species effects on ecosystem processes. Each of these more conceptual topics will be discussed in concert with their applications to the conservation and management of species and communities in a changing world.
B. Concept Courses and Applications

Advanced Concept Classes

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0263-01L</td>
<td>Seminar in Evolutionary Ecology of Infectious Diseases</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>R. R. Regös, S. Bonhoeffer</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td>Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.</td>
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<td></td>
<td>Objective</td>
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<td>This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.</td>
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<tr>
<td></td>
<td>Content</td>
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<td>A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.</td>
</tr>
<tr>
<td></td>
<td>Literature</td>
<td></td>
<td></td>
<td></td>
<td>Publications and class notes can be downloaded from a web page announced during the lecture.</td>
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<tr>
<td></td>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td>none</td>
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<tr>
<td></td>
<td>Literature</td>
<td></td>
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<td></td>
<td>Active and regular participation in the discussions, together with the presentation of a scientific paper are required to successfully pass this course.</td>
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<tr>
<td></td>
<td>Prerequisites / notice</td>
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<td></td>
<td>It is strongly recommended that participants have in advance successfully participated in the course Evolutionary Genetics (701-2413-00) or Ecological Genetics (701-1413-01).</td>
</tr>
<tr>
<td>701-1409-00L</td>
<td>Research Seminar: Ecological Genetics</td>
<td>W</td>
<td>2</td>
<td>1S</td>
<td>S. Flor</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
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<td></td>
<td>In this research seminar we will critically discuss recent publications on current topics in Ecological Genetics.</td>
</tr>
<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>It is our aim that participants gain insight into current research topics and approaches in Ecological Genetics and learn to critically assess and appreciate scientific publications in this field.</td>
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<tr>
<td></td>
<td>Lecture notes</td>
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<td>none</td>
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<tr>
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<td></td>
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</tr>
<tr>
<td>701-1471-00L</td>
<td>Ecological Parasitology</td>
<td>W</td>
<td>3</td>
<td>1V+1P</td>
<td>F. A. A. Feijen, J. Jokela, C. Vorburger</td>
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<tr>
<td></td>
<td>Number of participants limited to 20.</td>
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<td>A minimum of 6 students is required that the course will take place.</td>
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<td>Waiting list will be deleted on 30.09.2022</td>
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<tr>
<td></td>
<td>Abstract</td>
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<td>Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.</td>
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<tr>
<td></td>
<td>Objective</td>
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<td></td>
<td>1. Identify common macroparasites in invertebrates.</td>
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<td>2. Understand ecological and evolutionary processes in host-parasite interactions.</td>
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<td>3. Conduct parasitological research</td>
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<td>Content</td>
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<td>Lectures:</td>
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<td></td>
<td>1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).</td>
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<td>2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).</td>
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<td>3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).</td>
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<td>4. Ecology and evolution of parasitoids and their applications in biocontrol</td>
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<td>5. Human macroparasites (schistosomiasis, malaria).</td>
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<td>Practical exercises:</td>
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<td></td>
<td>1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).</td>
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<td>2. Examination of parasites in amphipods (identification and examination of effects on hosts).</td>
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<td></td>
<td>3. Examination of parasitoids of aphids.</td>
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<td>Prerequisites / notice</td>
<td></td>
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<td>The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübdorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.</td>
</tr>
<tr>
<td>701-1676-01L</td>
<td>Genomics of Environmental Adaptation</td>
<td>W</td>
<td>2</td>
<td>3G</td>
<td>R. Holderegger, F. Gugerli, C. Rellstab</td>
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<td>Number of participants limited to 14.</td>
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<td>Prerequisites: good knowledge in population genetics and some experience in using GIS and R is required.</td>
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</table>
This five-day winter school aims at teaching advanced Master students, PhD students and postdoctoral researchers on aspects of the genetics of environmental adaptation. It provides both theoretical background and hands-on exercises on major topics of contemporary environmental genomics such as signatures of selection, outlier analysis, environmental association analysis or GWAS.

**Content**

Topics:
1. Neutral and adaptive genetic variation, neutral genetic structure; genomic markers and next generation sequencing techniques.
2. Outlier analysis; concept and methodology of outlier analysis; diverse types of outlier analyses
3. Environmental data: which environmental data are available and used to identify signatures of adaptation; data limitations; collinearity.
4. Environmental association analysis (landscape genomics): concept and types of environmental association analysis; genomic offset.
5. Genotypes and phenotypes: GWAS; follow-up analyses

**Literature**

Hand-outs will be distributed.

The course requires 4 hours of preparatory reading of selected papers on the genetics of environmental adaptation. The papers will be distributed by e-mail.

Grading will be according to a written report (6-8 pages), in which students will have to design a complete study in environmental genomics, and according to student contributions during the course.

Prerequisites:
- Must have good knowledge in population genetics and evolutionary biology and basic skills in R; experience with GIS is advantageous.

**Prerequisites / notice**

A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.

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**636-0017-00L**

**Computational Biology**

The aim of the course is to provide up-to-date knowledge on how we can study biological processes using genetic sequencing data. Computational algorithms extracting biological information from genetic sequence data are discussed, and statistical tools to understand this information in detail are introduced.

**Objective**

Attendees will learn which information is contained in genetic sequencing data and how to extract information from this data using computational tools. The main concepts introduced are:

- stochastic models in molecular evolution
- phylogenetic & phylodynamic inference
- maximum likelihood and Bayesian statistics

Attendees will apply these concepts to a number of applications yielding biological insight into:

- * epidemiology
- * pathogen evolution
- * macroevolution of species

**Content**

The course consists of four parts. We first introduce modern genetic sequencing technology, and algorithms to obtain sequence alignments from the output of the sequencers. We then present methods for direct alignment analysis using approaches such as BLAST and GWAS. Second, we introduce mechanisms and concepts of molecular evolution, i.e. we discuss how genetic sequences change over time. Third, we employ evolutionary concepts to infer ancestral relationships between organisms based on their genetic sequences, i.e. we discuss methods to infer genealogies and phylogenies. Lastly, we introduce the field of phylogenomics, the aim of which is to understand and quantify population dynamic processes (such as transmission in epidemiology or speciation & extinction in macroevolution) based on a phylogeny. Throughout the course, the models and methods are illustrated on different datasets giving insight into the epidemiology and evolution of a range of infectious diseases (e.g. HIV, HCV, influenza, Ebola). Applications of the methods to the field of macroevolution provide insight into the evolution and ecology of different species clades. Students will be trained in the algorithms and their application both on paper and in silico as part of the exercises.

**Prerequisites / notice**

Waiting list will be deleted 19.01.2023.

**Literature**

The course is not based on any of the textbooks below, but they are excellent choices as accompanying material:

- Drummond, A. & Bouckaert, R. 2015. Bayesian evolutionary analysis with BEAST.
This course focuses on the interactions between ecology, biogeochemistry and management of agro- and forest ecosystems, thus, coupled human-environmental systems. Students learn how human impacts on ecosystems via management or global change are mainly driven by effects on biogeochemical cycles and thus ecosystem functioning, but also about feedback mechanisms of terrestrial ecosystems.

Objectives

Students will analyse and understand the complex and interacting processes of ecology, biogeochemistry and management of agroecosystems, be able to analyze large meteorological and flux data sets, and evaluate the impacts of weather events and management practices, based on real-life data. Moreover, students will be able to coordinate and work successfully in small (interdisciplinary) teams.

Content

Agroecosystems play a major role in all landscapes, either for production purposes, ecological areas or for recreation. The human impact of any management on the environment is mainly driven by effects on biogeochemical cycles. Effects of global change impacts will also act via biogeochemistry at the soil-biosphere-atmosphere-interface. Thus, ecosystem functioning, i.e., the interactions between ecology, biogeochemistry and management of terrestrial systems, is the science topic for this course.

Students will gain profound knowledge about biogeochemical cycles and greenhouse gas fluxes in managed grassland and/or cropland ecosystems. Responses of agroecosystems to the environment, i.e., to climate and weather events, but also to management will be studied. Different meteorological and greenhouse gas flux data will be analysed (using R) and assessed in terms of production, greenhouse gas budgets and carbon sequestration. Thus, students will learn about the complex interactions of a coupled human-environmental system.

Students will work with real-life data from the long-term measurement network Swiss FluxNet. Data from the intensively managed grassland site Chamau will be used to investigate the biosphere-atmosphere exchange of CO2, H2O, N2O and CH4. Functional relationships will be identified, greenhouse gas budgets will be calculated for different time periods and in relation to management over the course of a year.

Lecture notes

Handouts will be available in moodle.

Prerequisites / notice

Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Method-specific Competencies

- Critical Thinking
- Self-direction and Self-management

Personal Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Handouts will be available in moodle.

Prerequisites: Attendance of introductory courses in plant ecophysiology, ecology, and grassland or forest sciences. Knowledge of data analyses in R and statistics. Course will be taught in English.

Fostered competencies

Subject-specific Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Method-specific Competencies

- Critical Thinking
- Self-direction and Self-management

Personal Competencies

- Concepts and Theories
- Analytical Competencies
- Decision-making
- Problem-solving

Applications

**Autumn Semester 2022**

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>701-1453-00L</td>
<td>Ecological Assessment and Evaluation</td>
<td>W</td>
<td>3 credits</td>
<td>3G</td>
<td>F. Knaus</td>
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<tr>
<td>701-1613-01L</td>
<td>Advanced Landscape Research</td>
<td>W</td>
<td>5 credits</td>
<td>3G</td>
<td>L. Pellissier, U. Gimmi, M. Hunziker</td>
</tr>
</tbody>
</table>

*Does not take place this semester.*

Objective

Students will be able to:

1. critically consider biological data books and local, regional, and national inventories;
2. evaluate the validity of ecological criteria used in decision making processes;
3. critically appraise the handling of ecological data and criteria used in the process of evaluation;
4. perform an ecological evaluation project from the field survey up to the decision making and planning.

Literature

Basic literature and references are listed on the webpage.

Prerequisites / notice

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:

- Pflanzen- und Vegetationsökologie
- Systematische Botanik
- Raum- und Regionalentwicklung
- Naturschutz und Naturschutzbiologie

This course introduces landscapes as socially perceived, spatially and temporally dynamic entities that are shaped by natural and societal factors. Concepts and qualitative and quantitative methods to study landscapes from an ecological, societal and historical perspective are presented. In a term paper students work on a landscape-related topic of their choice.

Objective

Students will:

- learn about concepts and methods to quantify structural and functional connectivity in landscapes, particularly
- be introduced to the topic of landscape genetics and its benefits and (current) limitations for applied conservation
- learn about concepts and methods in scenario-based land-use change modelling
- approach an understanding of landscape as perceived environment
- learn about concepts of landscape preference and related measurement methods
- understand the role of landscape for human well-being
- be introduced into approaches of actively influencing attitudes and behavior as well as related scientific evaluation
- make use of various historical sources to study landscapes and their dynamics
- interpret landscapes as a result of ecological constraints and anthropogenic activities.
1. Encompassing concepts and approaches
- European Landscape Convention (ELC)
- Ecosystem Services (ES); introduction and critical evaluation

Thematic topics
2. Ecological approach:
- green infrastructure (e.g., ecological conservation areas)
- landscape connectivity
- landscape genetics and management applications
- concepts of specific quantitative methods: least cost paths, resistance surfaces, Circuitscape, networks (Conefor), land-use change models, various statistical methods

3. Social-science approach:
- principle of landscape as perceived and connoted environment
- theories on landscape preference and place identity
- role of landscapes for recreation, health and well-being
- intervention approaches for influencing attitudes and related behavior
- methods of investigating the human-landscape relationship and evaluating interventions

4. Historical approach:
- land use history of Switzerland (agricultural history, forest and woodland history)
- historical legacies of land use in landscapes and ecosystems
- historic-ecological approaches and applications

5. Land change science:
- modelling future land-use (CLUE, other scenario-based models)
- landscape functions and services

Lecture notes
Handouts will be available in the course and for download

Prerequisites / notice
Basic Landscape Ecology courses at Bachelor level

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-1631-00L</td>
<td>Foundations of Ecosystem Management</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>J. Ghazoul, A. Giger Dray</td>
</tr>
</tbody>
</table>

Priority is given to the target groups until 26.09.2022,

Waiting list will be deleted on 30.09.2022

This course introduces the broad variety of conflicts that arise in projects focusing on sustainable management of natural resources. It explores case studies of ecosystem management approaches and considers their practicability, their achievements and possible barriers to their uptake.

Students should be able to:
- a) propose appropriate and realistic solutions to ecosystem management problems that integrate ecological, economic and social dimensions across relevant temporal and spatial scales.
- b) identify important stakeholders, their needs and interests, and the main conflicts that exist among them in the context of land and resource management.

Content
Traditional management systems focus on extraction of natural resources, and their manipulation and governance. However, traditional management has frequently resulted in catastrophic failures such as, for example, the collapse of fish stocks and biodiversity loss. These failures have stimulated the development of alternative ecosystem management approaches that emphasise the functionality of human-dominated systems. Inherent to such approaches are system-wide perspectives and a focus on ecological processes and services, multiple spatial and temporal scales, as well as the need to incorporate diverse stakeholder interests in decision making. Thus, ecosystem management is the science and practice of managing natural resources, biodiversity and ecological processes, to meet multiple demands of society. It can be local, regional or global in scope, and addresses critical issues in developed and developing countries relating to economic and environmental security and sustainability.

This course provides an introduction to ecosystem management, and in particular the importance of integrating ecology into management systems to meet multiple societal demands. The course explores the extent to which human-managed terrestrial systems depend on underlying ecological processes, and the consequences of degradation of these processes for human welfare and environmental wellbeing. Building upon a theoretical foundation, the course will tackle issues in resource ecology and management, notably forests, agriculture and wild resources within the broader context of sustainability, biodiversity conservation and poverty alleviation or economic development. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

C. Scientific Skills

Quantitative and Computational Expertise

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<tbody>
<tr>
<td>701-1677-00L</td>
<td>Quantitative Vegetation Dynamics: Models from Tree to Globe</td>
<td>W</td>
<td>3</td>
<td>3G</td>
<td>H. Lischke, U. Hiltner, B. Rohner</td>
</tr>
</tbody>
</table>
Abstract
The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience.

Objective
Students will
- be enabled to understand, assess and evaluate the fundamental properties of dynamic systems using vegetation models as case studies
- obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level
- understand the basic assumptions of the various model types, which dictate the applicability and limitations of the respective model
- be enabled to work with such model types on their own
- appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems.

Content
Models of individuals
- Deriving single-plant models from inventory measurements
- Plant models based on "first principles"

Models at the stand scale
- Simple approaches: matrix models
- Competition for light and other resources as central mechanisms
- Individual-based stand models: distance-dependent and distance-independent
- Theoretical models

Models at the landscape scale
- Simple approaches: cellular automata
- Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms
- Landscape models

Global models
- Sacrificing local detail to attain global coverage: processes and entities
- Dynamic Global Vegetation Models (DGVMs)
- DGVMs as components of Earth System Models

Lecture notes
Handouts will be available in the course and for download

Literature
Will be indicated at the beginning of the course

Prerequisites / notice
- Ideally basic experiences in modelling and systems analysis
- Basic knowledge of programming, ideally in R
- Good knowledge of general ecology, ideally of vegetation dynamics and forest systems

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<tr>
<td>701-1679-00L</td>
<td>Ecology Modelling of Biodiversity: From Global Changes to Conservation</td>
<td>W</td>
<td>5</td>
<td>3G</td>
<td>L. Pellissier, C. Graham, N. Zimmermann</td>
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</table>

Abstract
The course provides the student with the spatial tools to address societal challenges toward ensuring the sustainable use of terrestrial ecosystems and the conservation of biodiversity. Students learn theory, tools and models during a few introductory sessions and apply this knowledge to solve a practical problem in groups related to climate change, land use change and biodiversity conservation.

Objective
Students learn:
- Theoretical foundations of the species ecological niche
- Biodiversity concepts and global change impacts
- Advanced statistical methods (GLM, GAM, CART) and basic programming (loops, functions, advanced scripting) in the statistical environment R.
- The use of GIS functionality in R

Content
1. The basics:
   - Introduction to the concept of the ecological niche, and biodiversity theories. Overview of the knowledge on expected biodiversity response to global changes and conservation planning methods.

2. The class project:
   - Students form groups of two, and each group solves a series of applied questions independently in R using the techniques taught in the introductory classes. The students then prepare a presentation and report of the obtained results that will be discussed during a mini-symposium. Each team choses one of the following topics for the class project:
     a) Linking climate change velocities to species' migration capacities
     b) Explaining and modelling land use change in Switzerland
     c) Explaining and modelling biodiversity changes in Switzerland
     d) Designing biodiversity conservation strategies under global changes.

Prerequisites / notice
Basic knowledge in statistics (OLS regression, test statistics), and basic knowledge in geographic information science.

Laboratory and Field Expertise

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<tr>
<td>701-1425-01L</td>
<td>Genetic Diversity: Techniques</td>
<td>W</td>
<td>2</td>
<td>4P</td>
<td>A. M. Minder Pyly</td>
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Waiting list will be deleted 08.11.22.
No enrollment possible after 31.10.22.

Abstract
This course provides laboratory training for advanced students (master, doctoral or post-doctoral level). Different DNA/RNA extraction protocols, quality control measurements, SNP genotyping and gene expression techniques will be addressed. This is a course for practitioners.

Objective
To learn and improve on standard and modern methods of genetic data collection. With a focus on: Use of different extraction protocols, techniques for quality control measurements, gene expression, pyrosequencing and other SNP genotyping techniques.

Content
After an introduction (one afternoon), students have 3 weeks to work independently in groups of two on different protocols. At the end of this practical part, the whole class meets for another afternoon to present the techniques/results and to discuss the advantages and disadvantages of the different techniques.

Techniques addressed are: DNA/RNA extractions and quality control, SNP genotyping, pyrosequencing, real-time qPCR.

Lecture notes
Material will be handed out in the course.

Literature
Material will be handed out in the course.

Prerequisites / notice
Two afternoons are held in the class. The lab work will be done from the students according to their timetable, but has to be finished after 3 weeks. Effort is roughly 1-2 full days per week, depending on the skills of the student.
This course combines Limnology (the study of inland waters in its broad sense) with ecological and evolutionary concepts. It deals with rivers, groundwater and lakes.

**Objective**

During this course you will get an overview of the world's typical freshwater ecosystems. After this course you will be able to understand how aquatic organisms have adapted to their habitat and how the interactions (e.g. food web) between organisms work. In short: apply the theoretical / lecture knowledge to field situations in a lake and river.

**Content**

The lectures cover ecology and evolution of aquatic organisms in lentic and lotic waters. Topics include: Adaptations, distribution patterns, biotic interactions, and conceptual paradigms in freshwater ecosystems. Important aspects regarding ecosystem metabolism and habitat properties of freshwaters. Applied case studies and experiments testing ecological and evolutionary processes in freshwaters.

The lectures are given by Piet Spaak (Eawag), Florian Altermatt (UNI, Eawag), Chris Robinson (Eawag), Francesco Pomati (Eawag), Anita Narwani (Eawag) and specialists from the Aquatic Ecology department of Eawag and University of Zurich.

**Lecture notes**

Course notes and power point presentations provided during the course.

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**Expertise in Biological Diversity**

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<tbody>
<tr>
<td>701-1437-01L</td>
<td>Practical Course Macroinvertebrates</td>
<td>W</td>
<td>2</td>
<td>2P</td>
<td>J. Jokela</td>
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<tr>
<td></td>
<td>The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses &quot;701-1437-00 Aquatic Ecology I&quot;, &quot;701-1437-03 Aquatic Ecology II&quot; and &quot;701-1437-02 Bestimmungskurs Süßwasserorganismen und aquatische Mikroinvertebraten&quot; are given priority. Sign in until 15.08.2022, free places will be distributed after that. Students registering later cannot be guaranteed a place in the course.</td>
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<td>This course gives an overview of the typical aquatic macroinvertebrate groups in Switzerland. Beside a theoretical background on the different groups the focus is laid on the determination of the most important species groups and their identification traits, also using identification keys. Practical experience in benthic sampling techniques is collected during an excursion. After this course you will be able to identify the most important aquatic species groups at the level of order/family and know the most important identification traits. You will also be able to use identification literature commonly used in Switzerland. During an excursion, you will apply the theoretical / lecture knowledge to field situations in a lake and river.</td>
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<td>Registration for the course until 15.08.2022, free places will be distributed later. Students registrating later cannot be guaranteed a place in the course.</td>
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<tr>
<td>701-1437-02L</td>
<td>Identification Course Freshwater Algae and Aquatic Microinvertebrates</td>
<td>W</td>
<td>2</td>
<td>2P</td>
<td>J. Jokela</td>
</tr>
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<td>This course builds on Aquatic Ecology I and cannot be taken separately. It aims on extending the covered concepts and apply them to natural and experimental systems. The course contains research projects, a 1-day excursion to a lake as well as a 3-day excursion to a river. During the research project you will learn the principles of doing research to observe interrelations in aquatic ecosystems. You will measure and interpret biological and physical data (e.g. during experiments, field work). You will present the collected knowledge and write a report about it. During the excursions you will get to know a lake system as well as a river system. The main goal of the excursions is that the students as a team conduct their own field research project and collect data in the field.</td>
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<td>The field excursions contain a 1-day excursion to a lake (Greifensee) and a 3-day excursion to a river (Glatt, Niederuzwil). The experimental part contains research projects in small groups within research groups at Eawag.</td>
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<td>This course can only be taken together with &quot;701-1437-00 Aquatic Ecology I&quot;, &quot;701-1437-01 Bestimmungskurs aquatische Makroinvertebraten&quot; and &quot;701-1437-02 Bestimmungskurs Süßwasserorganismen und aquatische Mikroinvertebraten&quot;.</td>
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<td></td>
<td>The course includes a mandatory field trip to Greifensee (22.09.2022) and a three-day excursion to the river Glatt (28.-30.09. 2022).</td>
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</tbody>
</table>
In-depth introduction into microbial evolution and ecology, especially the aspects that are the focus of on-going research in this area at Environmental Systems Data Science: Data Seminar in Microbial Evolution and Ecology (HS)

ECTS Type Hours
- Students acquire a thorough knowledge on a topic in which they are particularly interested Seminar of the groups Molecular Microbial S. Bonhoeffer
Topics for the essays are proposed by the professors and lecturers of the major in Ecology and Evolution at a joint meeting at the beginning of the semester (the date will be communicated by e-mail to registered students). Students will:
- choose a topic
- search and read appropriate literature
- develop a personal view on the topic and structure their arguments
- prepare figures and tables to represent ideas or illustrate them with examples
- write a clear, logical and well-structured text
- refine the text and present the paper according to professional standards

Course notes and power point presentations provided during the course.

The maximal participating number of students is 9 from D-USYS and 16 from D-BIOL. In case of too many students, those that simultaneously participate in the courses "701-1437-00 Aquatic Ecology I” and "701-1437-01 Bestimmungskurs aquatischer Makroinvertebraten" are given priority. Sign in until 15.08.2022 free places will be distributed after that. Students registrating later cannot be guaranteed a place in the course.

The excursion takes place Thursday 20.10.2022 from 1pm-5pm.

Seminar and Semester Paper

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1460-00L</td>
<td>Ecology and Evolution: Term Paper ■</td>
<td>O</td>
<td>5 credits</td>
<td>1A</td>
<td>T. Staedler, J. Alexander, S. Bonhoeffer, T. Crowther, A. Hall, J. Hille Ris Lambers, J. Jokela, J. Payne, G. Velicer, A. Widmer</td>
</tr>
</tbody>
</table>

Abstract
Individual writing of an essay-type review paper about a specialized topic in the field of ecology and evolution, based on substantial reading of original literature and discussions with a senior scientist.

Objective
- Students acquire a thorough knowledge on a topic in which they are particularly interested
- They learn to assess the relevance of original literature and synthesize information
- They make the experience of becoming "experts" on a topic and develop their own perspective
- They practise academic writing according to professional standards in English

Content
Topics for the essays are proposed by the professors and lecturers of the major in Ecology and Evolution at a joint meeting at the beginning of the semester (the date will be communicated by e-mail to registered students).

Lecture notes
Reading of articles in scientific journals.

Prerequisites / notice
The "Term Paper" requires considerable time set aside to read and digest original scientific literature, culminating in the writing of a review paper. The submission deadline is the first day of the spring semester, implying that much of the actual writing will be performed in January and February. Grading is based on the quality of the submitted review paper (2/3 of total grade), and on the "soft skills" such as the level of initiative, timeliness, independence, etc. of the student (1/3 of total grade). The personal supervisor is charged with grading the student's performance.

Electives

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0290-00L</td>
<td>Seminar in Microbial Evolution and Ecology (HS)</td>
<td>Z</td>
<td>0 credits</td>
<td>2S</td>
<td>S. Bonhoeffer</td>
</tr>
</tbody>
</table>

Abstract
Seminar of the groups Molecular Microbial Ecology, Theoretical Biology, Experimental Ecology, Evolutionary Biology. Talks given by members of these groups and external visitors.

Objective
In-depth introduction into microbial evolution and ecology, especially the aspects that are the focus of on-going research in this area at Department of Environmental Systems Science.

Environmental Systems Data Science: Data Processing

**Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.**

Number of participants is limited to 80.

Course registration starts on 31.08.2022
Priority is given to the target groups until 23.09.2022,

Target groups
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022.
Abstract

Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective

The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content

- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
252-0640-02L Anwendungnahme Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning

Number of participants is limited to 80.

Course registration starts on 31.08.2022.
PRIORITY IS GIVEN TO THE TARGET GROUPS UNTIL 23.09.2022.

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract

Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods.

Objective

The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content

- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature
Building on existing data science resources

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

551-0205-00L Challenges in Plant Sciences

Number of participants limited to 40.

Abstract

The colloquium “Challenges in Plant Sciences” is a core class of the Zurich-Basel Plant Science Center’s PhD program and the MSc module. The colloquium introduces participants to the broad spectrum of plant sciences within the network. The course offers the opportunity to approach interdisciplinary topics in the field of plant sciences.

Objective

Objectives of the colloquium are:

Introduction to resecent research in all fields of plant sciences
Working in interdisciplinary teams on the topics
Developing presentation and discussion skills

Content

The topics encompass integrated knowledge on current plant research, ranging from the molecular level to the ecosystem level, and from basic to applied science while making use of the synergies between the different research groups within the PSC.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories

Method-specific Competencies
- Analytical Competencies
- Communication
- Cooperation and Teamwork

Social Competencies
- Self-direction and Self-management

Personal Competencies
- assessed
- assessed
- assessed
- assessed
- not assessed
- not assessed

751-4504-00L Plant Pathology I

Abstract

Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems.
Objective

Students will understand: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems as a basis for implementing disease management strategies in agroecosystems.

Content

Course description: Plant Pathology I will focus on pathogen-plant interactions, epidemiology, disease assessment, and disease development in agroecosystems. Themes will include: 1) how pathogens attack plants and; 2) how plants defend themselves against pathogens; 3) factors driving the development of epidemics in agroecosystems. Topics under the first theme will include pathogen life cycles, disease cycles, and an overview of plant pathogenic nematodes, viruses, bacteria, and fungi. Topics under the second theme will include plant defense strategies, host range, passive and active defenses, and chemical and structural defenses. Topics under the third theme will include the disease triangle and cultural control strategies.

Lecture Topics and Tentative Schedule

Week 1  The nature of plant diseases, symbiosis, parasites, mutualism, biotrophs and necrotrophs, disease cycles and pathogen life cycles.
Week 2  Nematode attack strategies and types of damage. Viral pathogens, classification, reproduction and transmission, attack strategies and types of damage. Examples TMV, BYDV. Bacterial pathogens and phytoplasmas, classification, reproduction and transmission.
Week 3  Bacterial attack strategies and symptoms. Example bacterial diseases: fire blight, Agrobacterium crown gall, soft rots. Fungal and oomycete pathogens, classification, growth and reproduction, sexual and asexual spores, transmission.
Week 4  Fungal and oomycete life cycles, disease cycles, infection processes, colonization, phytoalexins and mycotoxins. Attack strategies of fungal necrotrophs and biotrophs. Symptoms and signs of fungal infection. Example fungal diseases: potato late blight.
Week 5  Example fungal diseases: wheat stem rust, grape powdery mildew, wheat septoria tritici blotch. Plant defense mechanisms, host range and non-host resistance. Passive structural and chemical defenses, preformed chemical defenses. Active structural defense, histological and cellular (papillae).
Week 6  Active chemical defense, hypersensitive response, pathogenesis-related (PR) proteins, phytoalexins and disease resistance. Pisatin and pisatin demethylase. Local and systemic acquired resistance (LAR, SAR), induced systemic resistance (ISR), signal molecules, defense activators (Bion). Pathogen effects on food quality. Positive and negative transformations.
Week 8  Epidemiology: Disease pyramid, environmental effects on epidemic development, plant effects on development of epidemics, including resistance, physiology, density, uniformity.
Week 9  Disease assessment: incidence and severity measures, keys, diagrams, scales, measurement errors. Correlations between incidence and severity. Molecular detection and diagnosis of pathogens. Host indexing, serology, monoclonal and polyclonal antibodies, ELISA.
Week 10  Molecular detection and diagnosis of pathogens: PCR, rDNA and loop-mediated isothermal amplification. Strategies for minimizing disease risks: calculating disease thresholds, disease forecasting systems.
Week 12  Physical control methods. Cultural control methods: avoidance, tillage practices, crop sanitation.
Week 13  Cultural control methods: fertilizers, crop rotations.
Week 14  Open lecture.

Lecture notes

Major in Environmental Systems Policy

Theoretical Foundations for Environmental Policy

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1563-00L</td>
<td>Climate Policy</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>A. Patt, S. Hanger-Kopp</td>
</tr>
</tbody>
</table>

This course provides an in-depth analysis both of the theoretical underpinnings to different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It's a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

Objective

Analytical Competencies

Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

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Objective

Environmental Governance

Number of participants is limited to 30.

Priority is given to the target groups until 19.09.2022,

Target groups: Environmental Sciences MSc, Agricultural Sciences MSc

Waiting list will be deleted on 23.09.2022

Abstract

The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

Objective

To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To analyze the evolution as well as the key elements of environmental governance.

Content

Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

Key questions that this course seeks to answer: What are the core characteristics of environmental challenges from a policy perspective? What are key elements of 'environmental governance' and how legitimate and effective are these approaches in addressing persistent environmental challenges?

Literature


The Climate Casino, by William Nordhaus. Yale University Press.

Waiting list will be deleted on 23.09.2022

Priority is given to the target groups until 19.09.2022,

Target groups: Environmental Sciences MSc, Agricultural Sciences MSc

Waiting list will be deleted on 23.09.2022

Abstract

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Literature


The Climate Casino, by William Nordhaus. Yale University Press.

For more information, please visit the course page on Moodle.
We recommend that students have (a) a three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy).

### Prerequisites / notice

A detailed course schedule will be made available at the beginning of the semester. During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

### Fostered competencies

**Subject-specific Competencies**
- Concepts and Theories assessed

**Method-specific Competencies**
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed
- Project Management assessed

**Social Competencies**
- Communication assessed
- Cooperation and Teamwork assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity assessed
- Negotiation assessed

**Personal Competencies**
- Adaptability and Flexibility assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

### 851-0609-06L Governing the Energy Transition

**Abstract**
This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socioeconomic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.

**Objective**
- To gain an overview of the history of the transition of large technical systems
- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions
- To gain knowledge on the role of policy and politics in energy transitions

**Content**
Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary. This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback.

The grade will be determined by a final exam.

**Lecture notes**
Slides and reading material will be made available via moodle.ethz.ch (only for registered students).

**Literature**
A reading list will be provided via moodle.ethz.ch at the beginning of the semester.

**Prerequisites / notice**
This course is particularly suited for students of the following programmes: MA Comparative International Studies; MSc Energy Science & Technology; MSc Environmental Sciences; MSc Management, Technology & Economics; MSc Science, Technology & Policy; ETH & UZH PhD programmes.

### 860-0023-00L International Environmental Politics

**Abstract**
This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

**Objective**
The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

**Content**
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

**Lecture notes**
Reading materials and slides will be available via Moodle.

**Literature**
Reading materials and slides will be available via Moodle.

**Prerequisites / notice**
This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

### Modeling and Statistical Analysis

**Number**
W 3 credits 2V

**Title**
International Environmental Politics

**Type**
W

**ECTS**
3 credits

**Hours**
90 hours (meetings, reading assignments, preparation of test)

**Lecturers**
T. Bernauer
The course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn  

<table>
<thead>
<tr>
<th>701-1453-00L</th>
<th>Ecological Assessment and Evaluation</th>
<th>W</th>
<th>3 credits</th>
<th>3G</th>
<th>F. Knaus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The course provides methods and tools for ecological evaluations dealing with nature conservation or landscape planning. It covers census methods, ecological criteria, indicators, indices and critically appraises objectivity and accuracy of the available methods, tools and procedures. Birds and plants are used as main example guiding through different case studies.</td>
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</tbody>
</table>
| Objective    | Students will be able to:  
|              | 1) critically consider biological data books and local, regional, and national inventories;  
|              | 2) evaluate the validity of ecological criteria used in decision making processes;  
|              | 3) critically appraise the handling of ecological data and criteria used in the process of evaluation  
|              | 4) perform an ecological evaluation project from the field survey up to the descision making and planning. |
| Lecture notes| Powerpoint slides are available on the webpage. Additional documents are handed out as copies. |
| Literature   | Basic literature and references are listed on the webpage. |
| Prerequisites / notice | The course structure changes between lecture parts, seminars and discussions. The didactic atmosphere is intended as working group. |

Suggested prerequisites for attending this course are skills and knowledge equivalent to those taught in the following ETH courses:  
- Pflanzen- und Vegetatiosökologiele  
- Systematische Botanik  
- Raum- und Regionalentwicklung  
- Naturschutz und Naturschutzbiologie

<table>
<thead>
<tr>
<th>701-1565-00L</th>
<th>Quantitative Policy Analysis and Modeling</th>
<th>O</th>
<th>6 credits</th>
<th>4G</th>
<th>A. Patt, L. Booth, C. Moretti, T. Tröndle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The lectures will introduce students to the principles of quantitative policy analysis, namely the methods to predict and evaluate the social, economic, and environmental effects of alternative strategies to achieve public objectives. A series of individual assignments, and one group project, will give students an opportunity for students to apply those methods to a set of case studies</td>
<td></td>
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</tbody>
</table>
| Objective    | The objectives of this course are to develop the following key skills necessary for policy analysts:  
|              | - Identifying the critical quantitative factors that are of importance to policy makers in a range of decision-making situations.  
|              | - Developing conceptual models of the types of processes and relationships governing these quantitative factors, including stock-flow dynamics, feedback loops, optimization, sources and effects of uncertainty, and agent coordination problems.  
|              | - Develop program numerical models to simulate the processes and relationships, in order to identify policy problems and the effects of policy interventions.  
|              | - Communicate the findings from these simulations and associated analysis in a manner that makes transparent their theoretical foundation, the level and sources of uncertainty, and ultimately their applicability to the policy problem. The course will proceed through a series of policy analysis and modeling exercises, involving real-world or hypothetical problems. The specific examples around which work will be done will concern the environment, energy, health, and natural hazards management. |
| Fostered competencies | Subject-specific Competencies  
|                  | Concepts and Theories: assessed  
|                  | Techniques and Technologies: not assessed  
|                  | Method-specific Competencies  
|                  | Analytical Competencies: assessed  
|                  | Decision-making: assessed  
|                  | Media and Digital Technologies: assessed  
|                  | Problem-solving: assessed  
|                  | Project Management: not assessed  
|                  | Social Competencies  
|                  | Communication: assessed  
|                  | Personal Competencies  
|                  | Cooperation and Teamwork: not assessed  
|                  | Creative Thinking: assessed  
|                  | Critical Thinking: assessed  
|                  | Self-awareness and Self-reflection: not assessed  
|                  | Self-direction and Self-management: not assessed  

<table>
<thead>
<tr>
<th>101-0491-00L</th>
<th>Agent Based Modeling in Transportation</th>
<th>W</th>
<th>6 credits</th>
<th>4G</th>
<th>M. Balac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course provides an introduction to agent-based modeling in transportation. The lectures and exercises offer an opportunity to learn about agent-based models’ current methodology, focusing on MATSim, how agent-based models are set up, and perform a practical case study by working in teams.</td>
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| Objective    | At the end of the course, the students should:  
|              | - have an understanding of agent-based modeling  
|              | - have an understanding of MATSim  
|              | - have an understanding of the process needed to set up an agent-based study  
|              | - have practical experience of using MATSim to perform practical transportation studies |
| Content      | This course provides an introduction to agent-based models for transportation policy analysis. Four essential topics are covered:  
|              | 1) Introduction of agent-based modeling and its comparison to the traditional state of practice modeling  
|              | 2) Introduction of MATSim, an open-source agent-based model, developed at ETH Zurich and TU Berlin, and its various parts  
|              | 3) Setting up an agent-based model simulation, where different statistical methods used in the process will be introduced and explained. Here the open-source eqsim framework used at ETH Zurich to set up agent-based models will be introduced  
|              | 4) Conducting a transport policy study. The case study will be performed in groups and will include a paper-like report. |
| Literature   | Agent-based modeling in general  
|              | MATSim  
|              | Additional relevant readings, primarily scientific articles, will be recommended throughout the course. |
| Prerequisites / notice | There are no strict preconditions regarding which lectures the students should have previously attended. However, experience with at least one high-level programming language (Java, R, Python, or other) is recommended.  
|                  | Crash course 101-0491-10 Basics of Java and Best Practices for Scientific Computing before the start of HS is recommended. |

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<tr>
<th>363-0541-00L</th>
<th>Systems Dynamics and Complexity</th>
<th>W</th>
<th>3 credits</th>
<th>3G</th>
<th>F. Schweitzer</th>
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<td>Abstract</td>
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Finding solutions: what is complexity, problem solving cycle.

Implementing solutions: project management, critical path method, quality control feedback loop.

Controlling solutions: Vensim software, feedback cycles, control parameters, instabilities, chaos, oscillations and cycles, supply and demand, production functions, investment and consumption.

A successful participant of the course is able to:
- understand why most real problems are not simple, but require solution methods that go beyond algorithmic and mathematical approaches.
- apply the problem solving cycle as a systematic approach to identify problems and their solutions.
- calculate project schedules according to the critical path method.
- setup and run systems dynamics models by means of the Vensim software.
- identify feedback cycles and reasons for unintended systems behavior.
- analyse the stability of nonlinear dynamical systems and apply this to macroeconomic dynamics.

Why are problems not simple? Why do some systems behave in an unintended way? How can we model and control their dynamics? The course provides answers to these questions by using a broad range of methods encompassing systems oriented management, classical systems dynamics, nonlinear dynamics and macroeconomic modeling.

PART 1 introduces complexity as a system immanent property that cannot be simplified. It introduces the problem solving cycle, used in systems oriented management, as an approach to structure problems and to find solutions.

PART 2 discusses selected problems of project management when implementing solutions. Methods for identifying the critical path of subtasks in a project and for calculating the allocation of resources are provided. The role of quality control as an additional feedback loop and the consequences of small changes are discussed.

PART 3, by far the largest part of the course, provides more insight into the dynamics of existing systems. Examples come from biology (population dynamics), management (inventory modeling, technology adoption, production systems) and economics (supply and demand, investment and consumption). For systems dynamics models, the software program VENSIM is used to evaluate the dynamics. For economic models analytical approaches, also used in nonlinear dynamics and control theory, are applied. These together provide a systematic understanding of the role of feedback loops and instabilities in the dynamics of systems. Emphasis is on oscillating phenomena, such as business cycles and other life cycles.

Weekly self-study tasks are used to apply the concepts introduced in the lectures and to come to grips with the software program VENSIM. Another objective of the self-study tasks is to practice efficient communication of such concepts. These are provided as home work and two of these will be graded (see “Prerequisites”).

The lecture slides are provided as handouts - including notes and literature sources - to registered students only. All material is to be found on the Moodle platform. More details during the first lecture.

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<tr>
<td>701-1551-00L</td>
<td>Sustainability Assessment</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>P. Krüüli, D. Nef</td>
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Registration for the course is possible until 30.09.2022.
Waiting list will be deleted at the same date.

Abstract
The course teaches concepts and methodologies of sustainability assessment. A special focus is given to the social dimension and to social justice as a guiding principle of sustainability. The format of the course is seminar-like, interactive.

Objective
At the end of the course, students:
- know core concepts of sustainable development, main features of social justice in the context of sustainability, a selection of methodologies for the assessment of sustainable development;
- have a deepened understanding of the challenges of trade-offs between the different dimensions of sustainable development and their respective impacts on individual and societal decision-making.

Content
The course is structured as follows:
- overview of rationale, objectives, concepts and origins of sustainable development (approx. 15%)
- overview of the concept of social justice as guiding principle of the social dimension of sustainability (approx. 20%)
- analysis of a selection of concepts and methodologies to assess sustainable development in a variety of contexts (approx. 65%)

Lecture notes
Handouts are provided.

Literature
Selected scientific articles and book-chapters

Prerequisites / notice
Students of this course may also be interested in the course transdisciplinary case study (tdCS) in the Spring semester (701-1502-00L)

Fostered competencies
Subject-specific Competencies: Concepts and Theories assessed, Techniques and Technologies assessed.
Social Competencies: Communication not assessed, Cooperation and Teamwork not assessed.
Personal Competencies: Critical Thinking assessed.

701-1563-00L Climate Policy

Abstract
This course provides an in-depth analysis of both the theoretical underpinnings of different approaches to climate policy at the international and national levels, and how these different approaches have played out in practice. Students will learn how legislative frameworks have developed over the last 25 years, and also be able to appraise those frameworks critically.
Climate change is one of the defining challenges of our time, touching all aspects of the environment and of society. There is broad recognition (although with some dissent) that governments ought to do something about it: making sure that emissions of greenhouse gases (GHGs) stop within the next 30 to 40 years; helping people to adapt to the consequences of the climate change to which we have already committed ourselves; and, most controversially, perhaps taking measures to actively remove GHG’s from the atmosphere, or to alter the radiation balance of the Earth through solar engineering.

It’s a complicated set of problems, especially the first of these, known as mitigation. Fundamentally this is because it means doing something that humanity has never really tried before at a planetary scale: deliberately altering the ways the we produce, convert, and consume energy, which is at the heart of modern society. Modern society – the entire anthropocene – grew up on fossil fuels, and the huge benefits they offered in terms of energy that was inexpensive, easy to transport and store, and very dense in terms of its energy content per unit mass or volume. How to manage a society of over 7 billion people, at anything like today’s living standards, without the benefits of that energy, is a question for which there is no easy answer. There are also other challenges outside of energy. How do we build houses, office buildings, and infrastructure networks without cement, a substance that releases large amounts of CO2 as it hardens? How do we reverse the pace of deforestation, particularly in developing countries? How do we eliminate the GHG emissions from agriculture: the methane from cows’ bellies and rice paddies, together with the chemicals that enter the atmosphere from the application of fertilizer?

These are all tough questions at a technical level, but even tougher when you consider that governments typically need to employ indirect methods to get these things to happen. Arguably a government could simply pass a law that forbids people from using fossil fuels. But politically this is simply unrealistic, at least while so many people depend on fossil fuels in their daily lives. What is to be done? For this, one needs to turn to various ideas about how government can and should influence society. On the one hand are ideas suggesting that government ought to play a very limited role, relative to private actors, and should step in only to correct “market failures,” with interventions designed specifically around that failure. On the other hand are ideas suggesting that government (meaning all of us, working together through a democratic process) is the appropriate decision-making body for core decisions on where society can and should go. These issues come to the fore in climate policy discussions and debates.

This course is about all that. The goal is to give students a glimpse into the enormous complexity of this policy area, an understanding of some of the many debates that are currently raging (of which the debate about whether climate change is actually real is probably the least complicated or interesting). We want to give students the ability to evaluate policy arguments made by politicians, experts, and academics with a critical eye, informed by a knowledge of history, an understanding of the theoretical underpinnings, and the results of empirical testing of different strategies. A student taking this course ought to be able to step into an NGO or government agency involved in climate policy analysis or political advocacy, and immediately be able to make an informed and creative contribution. Moreover, by experiencing the depth of this policy area, students should be able to appreciate the complexity inherent in all policy areas.

There will be daily reading assignments, which we will then discuss critically during the class sessions. All of these will be posted in PDF format on a course Moodle. In addition, there will be two books to be read over the course of the semester. Both of these can be accessed from the ETH library or in PDF form free of charge. They are:

The Climate Casino, by William Nordhaus. Yale University Press.


Key challenges in international river systems

Water pollution and its mitigation

Nuts and bolts of hydrological modeling and what such models can tell us

Case study 1: Yarmuk
Case study 2: Mekong
Case study 3: Colorado
Case study 4: Nile
Case study 5: Central Asia

680-0012-00L Cooperation and Conflict Over International Water Resources

Number of participants limited to 40. Priority for Science, Technology, and Policy MSc.

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

Objective

Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

860-0012-00L Cooperation and Conflict Over International Water Resources

Number of participants limited to 40. Priority for Science, Technology, and Policy MSc.

This is a research seminar at the Master level. PhD students are also welcome. PhD students please register via the study administration.

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Ability to (1) understand the causes and consequences of water scarcity and water pollution problems in large international river systems; (2) understand ways and means of addressing such water challenges; and (3) analyse when and why international efforts in this respect succeed or fail.

Content

The first six meetings serve to acquire basic knowledge on the science and politics of international water management. This will be followed by five meetings that focus on specific cases (international river systems) and a meeting where we discuss what can be learned from the five cases. For this part of the class we have invited several colleagues with long-standing expertise on the respective international river basin.

20.Sep Global water challenges
27.Sep Nuts and bolts of hydrological modeling and what such models can tell us
04.Oct Nuts and bolts of hydrological modeling and what such models can tell us
11.Oct Water pollution and its mitigation
18.Oct Key challenges in international river systems
25.Oct Key challenges in international river systems
01.Nov Case study 1: Yarmuk
08.Nov Case study 2: Mekong
15.Nov Case study 3: Colorado
22.Nov Case study 4: Nile
29.Nov Case study 5: Central Asia
06.Dec Wrap up: what we can learn from these case studies
13.Dec Exam
20.Dec No class

Exam: 3 ECTS, based on grade ≥ 4.0 in written test at the end of the semester. 90 minutes; 13 December 2022, 12:15 – 13:45; same room as the course. The exam covers the mandatory reading assignments as well as lectures and discussion parts in class. The exam will consist of around ten questions that require answers in a few sentences each. Permitted supporting material: dictionary, ink-based pen, no laptops, no mobile phones, no calculators, no printed or hand-written material.
Lecture notes

Slides and reading materials will be made available via Moodle.

Literature

Slides and reading materials will be made available via Moodle.

Prerequisites / notice

The course is open to Master and doctoral students from any area of ETH.

Limited to 40 students.

Most meetings will take place on campus, with no recording of meetings. Participation in this course only makes sense if you can attend classes regularly in person.

### Electives

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<th>Number</th>
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<tr>
<td>701-3001-00L</td>
<td>Environmental Systems Data Science: Data</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne, M. Volpi</td>
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<td>&quot;Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.**</td>
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<td>Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.</td>
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<td>● frame a data science problem and build a hypothesis</td>
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<td>● describe the steps of a typical data science project workflow</td>
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<td>● conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models</td>
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<td>● critically think about the limits and implications of a method</td>
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<td>● visualise data and results throughout the workflow</td>
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<td>● access online resources to keep up with the latest data science methodology and deepen their understanding</td>
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<td></td>
<td>● The data science workflow</td>
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<td>● Access and handle (large) datasets</td>
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<td>● Prepare and clean data</td>
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<td>● Analysis: data exploratory steps</td>
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<td>● Analysis: machine learning and computational methods</td>
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<td>● Evaluate results and analyse uncertainty</td>
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<td>● Visualisation and communication</td>
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<td>252-0840-02L Anwendungsnahes Programmieren mit Python</td>
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<td>401-0624-00L Mathematik IV: Statistik</td>
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<td>401-6215-00L Using R for Data Analysis and Graphics (Part I)</td>
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<td>401-6217-00L Using R for Data Analysis and Graphics (Part II)</td>
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<td>701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt naturwissenschaften</td>
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<td>Environmental Systems Data Science: Machine</td>
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<td>Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning mode</td>
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<td>The students are able to</td>
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<td>● select an appropriate model related to a research question and dataset</td>
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<td>● describe the steps from data preparation to running and evaluating models</td>
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<td>● prepare data for running machine learning with dependent and independent variable</td>
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<td>● build and validate regressions and neural network models</td>
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<td>● understand convolution and deep learning models</td>
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<td></td>
<td>● The data science workflow</td>
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<td>● Data preparation for running and validating machine learning models</td>
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<td>● Get to know machine learning approaches including regression, random forest and neural network</td>
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<td>● Model complexity and hyperparameters</td>
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<td>● Model parameterization and loss</td>
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<td>● Model evaluations and uncertainty</td>
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<td>● Deep learning with convolutions</td>
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Streams are integrated monitors of the health and functioning of their surrounding landscapes. Streams integrate the fluxes of water, solutes, and sediment from their contributing catchment area; thus they reflect the spatially integrated hydrological, ecophysiological, and geomorphological processes in the surrounding landscape. At a practical level, there is a significant public interest in managing forested upland landscapes to provide a reliable supply of high-quality surface water and to minimize the risk of catastrophic flooding and debris flows, but the scientific background for such management advice is still evolving.

Students will have a broad understanding of the hydrological, biogeochemical, and geomorphological functioning of mountain catchments.

Using a combination of lectures, field exercises, and data analysis, we explore the processes controlling the delivery of water, solutes, and sediment to streams, and how those processes are affected by changes in land cover, land use, and climate. We review the connections between process understanding and predictive modeling in these complex environmental systems. How well can we understand the processes controlling watershed-scale phenomena, and what uncertainties are unavoidable? What are the relative advantages of top-down versus bottom-up approaches? How much can "black box" analyses reveal about what is happening inside the black box? Conversely, can small-scale, micro-mechanistic approaches be successfully "scaled up" to predict whole-watershed behavior? Practical problems to be considered include the effects of land use, atmospheric deposition, and climate on streamflow, water quality, and sediment dynamics, illustrated with data from experimental watersheds in North America, Scandinavia, and Europe.

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At the end of this course participants will be able:

- To carry out research on a given topic, identify relevant literature and present the results in a structured presentation and discuss the implications for forest management.
- To critically analyse conflicts and synergies resulting from different forest ecosystem services.
- To explain the various social expectations towards forest ecosystem services and their implications for multifunctional forest management.
- To describe forest management and silvicultural measures for enhancing forest resilience to climate change, increased disturbances, and invasive species, and evaluate their feasibility and effectiveness in various situations.
- To describe forest management and biodiversity in temperate forests.
- To describe forest management and silvicultural options for the management of multifunctional forests and critically evaluate their feasibility and suitability.
- To explain the various social expectations towards forest ecosystem services and their implications for multifunctional forest management.
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- To describe forest management and silvicultural options for the management of multifunctional forests and critically evaluate their feasibility and suitability.

Content

The course will cover important topics for the sustainable management of multifunctional forests and present silvicultural strategies to fulfil societal expectations. Case studies from tropical and temperate regions will be used to explore these issues. Dealing with ecological and economic uncertainty, and how this affects decision making, will be discussed. Strategies for conservation and management of terrestrial ecosystems will give consideration to landscape ecology, protected area systems, and community management, paying particular attention to alternative livelihood options and marketing strategies of common pool resources.

Lecture notes

No Script

Literature

### Fostered competencies

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed
- Problem-solving: assessed
- Project Management: assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: assessed
- Leadership and Responsibility: assessed
- Self-presentation and Social Influence: assessed

**Personal Competencies**
- Creative Thinking: assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: assessed

### Decision Making, Policy and Planning

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-1651-00L</td>
<td>Environmental Governance</td>
<td>W</td>
<td>6</td>
<td>3G</td>
<td>E. Lieberherr</td>
</tr>
</tbody>
</table>

**Number of participants is limited to 30.**

**Target groups:**
- Environmental Sciences MSc
- Agricultural Sciences MSc

**Waiting list will be deleted on 23.09.2022**

**Abstract**
The course addresses environmental policies, focusing on new steering approaches, which are generally summarized as environmental governance. The course also provides students with tools to analyze environmental policy processes and assesses the key features of environmental governance by examining various practical environmental policy examples.

**Objective**
To understand how an environmental problem may (not) become a policy and explain political processes, using basic concepts and techniques from political science.

To analyze the evolution as well as the key elements of environmental governance.

To be able to identify the main challenges and opportunities for environmental governance and to critically discuss them with reference to various practical policy examples.

**Content**
Improvements in environmental quality and sustainable management of natural resources cannot be achieved through technical solutions alone. The quality of the environment and the achievement of sustainable development strongly depend on human behavior and specifically the human uses of nature. To influence human behavior, we rely on public policies and other societal rules, which aim to steer the way humans use natural resources and their effects on the environment. Such steering can take place through government intervention alone. However, this often also involves governance, which includes the interplay between governmental and non-governmental actors, the use of diverse tools such as emission standards or financial incentives to steer actors' behavior and can occur at the local, regional, national or international level.

In this course, we will address both the practical aspects of as well as the scientific debate on environmental governance. The course gives future environmental experts a strong basis to position themselves in the governance debate, which does not preclude government but rather involves a spectrum from government to governance.

**Key questions that this course seeks to answer:**
- What are the core characteristics of environmental challenges from a policy perspective?
- What are key elements of ‘environmental governance’ and how legitimate and effective are these approaches in addressing persistent environmental challenges?

**Lecture notes**
Lecture slides, a script and additional course material will be provided on Moodle.

**Prerequisites / notice**
A detailed course schedule will be made available at the beginning of the semester.
During the lecture we will work with Moodle. We ask that all students register themselves on this platform before the lecture.

We recommend that students have (a) three-years BSc education of a (technical) university; (b) successfully completed Bachelor introductory course to environmental policy (Entwicklungen nationaler Umweltpolitik (or equivalent)) and (c) familiarity with key issues in environmental policy and some fundamental knowledge of one social science or humanities discipline (political science, economics, sociology, history, psychology, philosophy)

### Methods and Tools

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>701-1673-00L</td>
<td>Environmental Measurement Laboratory</td>
<td>W</td>
<td>5</td>
<td>4G</td>
<td>P. U. Lehmann Grunder, A. Carminati</td>
</tr>
</tbody>
</table>

**Number of participants limited to 24.**
Abstract
Measurements are the sole judge of scientific truth and provide access to unpredictable information, enabling the characterization and monitoring of complex terrestrial systems. Based on lectures and field- and laboratory training, the students learn to apply modern methods to determine forest inventory parameters and to measure subsurface properties and processes.

Objective
The students will be able to:
- explain measurement principles that are used for characterization of landscapes and terrestrial systems
- select appropriate measurement methods and sampling design to quantify key variables and processes above ground and in the subsurface
- deploy sensors in the field
- interpret collected laboratory and field data and report main conclusions deduced from measurements

Content
Week 1: Plant-Soil interactions – short introduction before sensor demonstration and installation in forest lab; Scholander pressure bomb (suction in leaves); LI-COR soil chamber

Week 2: Lecture on Measurement Science, overview of water content and water potential sensors; data logging and data logger programming; tests in the lab

Week 3: Introduction on soil physics; Field installation of sensors and field experiment; data collection for a few days; solar panel

Week 4: Soil sampling in field lab including geoprobe measurements

Week 5: Introduction on forest lab - Soil sampling in forest lab; root length density;

Week 6: Lecture on geophysical methods on Subsurface Characterization: Basic principles of ERT, GPR, and EM; simple lab tests on effective resistivity

Week 7: Demonstration and application of geophysical methods in the field

Week 8: Lecture on plant soil relationship; connecting information below and above ground – data analysis

Weeks 9 and 10: Forest characterization/ inventory: Principles of LiDAR; structures and features of the tree crowns, size/volume of the leaf area tree positions and diameters at breast height

Weeks 11 and 12: Eddy covariance methods -Principles for field measurement of water vapor, carbon dioxide, and energy exchange between terrestrial surfaces and the atmosphere; Analysis of measured time series to determine evaporation rate and CO2-fluxes

Week 13: Swiss Soil Monitoring networks – Monitoring of soil water content and potential; climate change and droughts

Week 14: Global data – Global modeling and data interpretation; SoilGrids and OpenLandMap; exercises on Budyko analysis

Literature
Lecture material will be online for registered students using moodle

Prerequisites / notice
The details of the schedule will be optimized based on the number of students; some blocks of the course will be offered as well to students of Environmental Engineering

701-1679-00L Landscape Modelling of Biodiversity: From Global Changes to Conservation

Does not take place this semester.

Abstract
The course provides the student with the spatial tools to address societal challenges toward ensuring the sustainable use of terrestrial ecosystems and the conservation of biodiversity. Students learn theory, tools and models during a few introductory sessions and apply this knowledge to solve a practical problem in groups related to climate change, land use change and biodiversity conservation.

Objective
Students learn:
- Theoretical foundations of the species ecological niche
- Biodiversity concepts and global change impacts
- Basic concepts of spatial (& macro-) ecology
- Environmental impact assessment and planning
- Advanced statistical methods (GLM, GAM, CART) and basic programming (loops, functions, advanced scripting) in the statistical environment R.
- The use of GIS functionality in R

1. The basics:
   Introduction to the concept of the ecological niche, and biodiversity theories. Overview of the knowledge on expected biodiversity response to global changes and conservation planning methods.

2. The class project:
   Students form groups of two, and each group solves a series of applied questions independently in R using the techniques taught in the introductory classes. The students then prepare a presentation and report of the obtained results that will be discussed during a mini-symposium. Each team choses one of the following topics for the class project:
   a) Linking climate change velocities to species’ migration capacities
   b) Explaining and modelling land use change in Switzerland
   c) Explaining and modelling biodiversity changes in Switzerland
   d) Designing biodiversity conservation strategies under global changes.

Prerequisites / notice
Basic knowledge in statistics (OLS regression, test statistics), and basic knowledge in geographic information science.

Electives
Natural Science Foundations

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<tr>
<th>Number</th>
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<tbody>
<tr>
<td>701-1620-00L</td>
<td>Tree Genetics – Concepts and Applications</td>
<td>W</td>
<td>3</td>
<td>2G</td>
<td>A. Rudow, F. Gugerli, C. Sperisen, N. Zimmermann</td>
</tr>
</tbody>
</table>

Abstract
Trees are important elements and drivers of ecosystem processes in forests and landscapes. Tree species diversity and intraspecific genetic diversity are relevant factors for continuous adaptation, required for a sustainable maintenance of forest products and services. Sustainable forest and landscape management under climate change has to take forest genetic resources into consideration.
Students will be able to:

The course provides a comprehensive overview on concepts and applications of tree genetics and complements basic knowledge of biology, dendrology, forest ecology and forest management in the frame of forest and landscape management topics. It introduces concepts of evolution and genetic methods as foundations, explains the most important processes and drivers of gene flow and adaptation, including coevolutionary aspects of associated organisms, and shows relevant topics of the management of genetic resources from reproduction to conservation and monitoring. Their theories and application into practice are illustrated on behalf of case studies on forest tree species. Two full-day excursions illustrate the contents with exemplary objects, actors and applications in Switzerland.

Lecture notes

Script: modular slide script (parts by each lecturer).

Literature


Prerequisites / notice

No mandatory prerequisites. Basic knowledge of dendrology and forest ecology is advantageous and recommended.

751-5125-00L Stable Isotope Ecology of Terrestrial Ecosystems

Objective

The educational goals of the course are:

To know basic concepts of evolution and molecular and quantitative methods of genetics.

To understand the most relevant processes of gene flow, adaptation and species interactions, on the basis of ecological theories and case studies on forest tree species.

To know management principles and instruments for the promotion and the conservation of forest genetic resources, with a view on application in practice.

Content

The course provides an overview about the applicability of stable isotopes (carbon 13C, nitrogen 15N, oxygen 18O and hydrogen 2H) to process-oriented ecological research. Topics focus on stable isotopes as indicators for the origin of pools and fluxes, partitioning of composite fluxes as well as to trace and integrate processes. In addition, students carry out a small project during lab sessions.

This course will provide an introduction to the applicability of stable isotopes to ecological research questions. Topics will focus on carbon (13C), nitrogen (15N), oxygen (18O) and hydrogen (2H) at natural isotope abundance and tracer levels. Lectures will be supplemented by intensive laboratory sessions, short presentations by students and computer exercises.

Lecture notes

Handouts will be available on the webpage of the course.

Literature

Will be discussed in class.

Prerequisites / notice

This course is based on fundamental knowledge about plant ecophysiology, soil science, and ecology in general. Course will be taught in English.

Fostered competencies

Subject-specific Competencies

Concepts and Theories

Techniques and Technologies

Method-specific Competencies

Analytical Competencies

Problem-solving

Project Management

Social Competencies

Communication

Personal Competencies

Creative Thinking

Self-direction and Self-management

ECTS

2 credits

2G

R. A. Werner, N. Buchmann, A. Gessler, M. Lehmann

Objective

The analyses of stable isotopes often provide insights into ecophysiological and ecological processes that otherwise would not be available with classical methods only. Stable isotopes proved useful to determine origin of pools and fluxes in ecosystems, to partition composite fluxes and to integrate processes spatially and temporally.

Content

The discipline of Forest operations is constantly challenged to find solutions for unique problems. Each forest site requires specific technological approaches and machinery based on given management goals and ecological and environmental circumstances. Various terrain types and soil conditions, harvesting costs and taking care of the workforce by creating safe working conditions are some of the a
Objective

In this course, students will learn to use a wide variety of approaches grounded in the natural sciences, engineering and technology to develop solutions tailored to unique challenges from the field of forest operations. The course is aimed at students who either plan an academic or professional career in the field of forest operations, or who will work at the interface between forest operations and the various related disciplines, such as forest ecosystem management and forestry in the wider sense.

After participating in this course students will have acquired foundational knowledge of a wide variety of core elements in the field of forest operations:

- The course will provide students with the ability to describe and differentiate site and stand conditions from an engineering perspective.
- Students will gain an overview and good working knowledge of current technology used in forest operations in Switzerland and around the world.
- Students will acquire the ability to assess the strength and weaknesses of the most commonly used equipment and analyze their suitability for a given set of environmental, economic and social factors.
- Students will be able to combine different types of technology to create an optimal harvesting system for a given task, and assess a given system for its task specific suitability.
- Participants will be able to assess the sustainability and potential short- and long-term impacts of harvesting systems under ecological, economic and social constraints.

Content

Introduction
- Historic overview
- Scope of operation
- Site and stand characteristics

Timber harvesting
- Logging methods
- Felling methods
- Motor- Manual felling methods
- Falling and processing
- Forest machine structure and function
- Harvester Technology
- Felling heads
- Carriers for felling heads
- Bunching
- Mechanical processing
- Loading equipment
- Operating techniques

Primary Transport Systems
- Ground based
  - Common features
  - Skidder
  - Forwarder
  - Loader Forwarder
- Cable yarding
  - Common features
  - Wire rope
  - Cable yarding systems
  - Operating techniques
- Aerial
  - Common features
  - Operating techniques

Winch-Assisted Harvesting Operations
- Harvesting
- Primary transport

Loading Equipment

Secondary transport
- Truck configurations
- Soil compaction and contamination
- Riparian areas

Forest Operations management
- Ergonomics
- Work Safety
- Economic Aspects
- Environmental impact assessment
- Equipment selection

Forest operations across the globe
- New Zealand
- North America
  - British Columbia, Canada
  - South-eastern U.S.A

Specialized equipment for small scale forest operations

Outlook into the future of forest operations

Literature

Published on Moodle

Prerequisites / notice

701-1544-00 Forest Access and Transportation

Decision Making, Policy and Planning

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>103-0468-00L</td>
<td>Participatory Environmental Modeling</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
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</table>

Does not take place this semester.
Abstract
The lecture accompanies students into a participatory modelling process. We explore environmental topics such as urban agriculture or climate-resilient city. Students will get to know participatory modelling tools as well as concepts and approaches related to it. Students elaborate the processes from questions to interactive operational models.

Objective
In this course students will learn:

- The process of developing a model to address an environmental problem: from choosing an appropriate technique (Agent-based modelling, Bayesian Networks and System dynamics), to conceptualization and model building.
- Communication and facilitation skills to foster effective and legitimate collaboration with stakeholders.

Students then apply this knowledge and skills to a real-life case study, creating a model with stakeholders to address an environmental problem.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<tr>
<td>Techniques and Technologies</td>
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<tr>
<td></td>
<td>Analytical Competencies</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
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<tr>
<td></td>
<td>Decision-making</td>
<td>Customer Orientation</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
<td>Leadership and Responsibility</td>
<td>Critical Thinking</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>Self-presentation and Social Influence</td>
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<td></td>
<td>Project Management</td>
<td>Sensitivity to Diversity</td>
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<td></td>
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<td>Negotiation</td>
<td>Integrity and Work Ethics</td>
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Methods and Tools

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>701-1316-00L</td>
<td>Physical Transport Processes in the Natural Environment</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>J. W. Kirchner</td>
</tr>
<tr>
<td>Abstract</td>
<td>Fluid flows transport all manner of biologically important gases, nutrients, toxins, contaminants, spores and seeds, as well as a wide range of organisms themselves. This course explores the physics of fluids in the natural environment, with emphasis on the transport, dispersion, and mixing of solutes and entrained particles, and their implications for biological and biogeochemical processes.</td>
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<tr>
<td>Objective</td>
<td>Students will learn key concepts of fluid mechanics and how to apply them to environmental problems. Weekly exercises based on real-world data will develop core skills in analysis, interpretation, and problem-solving.</td>
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<tr>
<td>Content</td>
<td>dimensional analysis, similarity, and scaling solute transport in laminar and turbulent flows transport and dispersion in porous media transport of sediment (and adsorbed contaminants) by air and water anomalous dispersion</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lecture notes</td>
<td>The course is under development. Lecture materials will be distributed as they become available.</td>
<td></td>
<td></td>
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</tbody>
</table>

| 701-1677-00L | Quantitative Vegetation Dynamics: Models from Tree to Globe | W    | 3 credits | 3G | H. Lischke, U. Hiltner, B. Rohner |
| Abstract | The course introduces basic concepts and applications of dynamic vegetation models at various temporal and spatial scales. Different modeling approaches and underlying principles are presented and critically discussed during the lectures. In the integrated exercise parts, students work in a number of small projects with some of the introduced models to gain practical experience. |
| Objective | Students will - be enabled to understand, assess and evaluate the fundamental properties of dynamic systems using vegetation models as case studies - obtain an overview of dynamic modelling techniques and their applications from the individual plant to the global level - understand the basic assumptions of the various model types, which dictate the applicability and limitations of the respective model - be enabled to work with such model types on their own - appreciate the methodological basis for impact assessments of future climate change and other environmental changes on ecosystems. |
| Content | Models of individuals - Deriving single-plant models from inventory measurements - Plant models based on 'first principles' Models at the stand scale - Simple approaches: matrix models - Competition for light and other resources as central mechanisms - Individual-based stand models: distance-dependent and distance-independent - Theoretical models Models at the landscape scale - Simple approaches: cellular automata - Dispersal and disturbances (windthrow, fire, bark beetles) as key mechanisms - Landscape models Global models - Sacrificing local detail to attain global coverage: processes and entities - Dynamic Global Vegetation Models (DGVMs) - DGVMs as components of Earth System Models |
| Lecture notes | Handouts will be available in the course and for download |
| Literature | Will be indicated at the beginning of the course |
The course dendroecology offers theoretical and practical aspects of dendrochronology. The impact of different environmental influences on tree-ring characteristics will be shown. The students learn various methods to date tree rings and they understand how ecological and environmental processes and patterns can be reconstructed using tree rings.

The students...
- understand, how wood is configured and how tree-ring structures are formed.
- are able to identify and describe different tree-ring structures.
- understand the theoretical and practical aspects of the dating of tree rings.
- know the effects of different abiotic and biotic environmental influences (climate, site, competition, insects, fire, physical-mechanical influences) on trees and tree rings.
- discover a tool for understanding and reconstructing global change processes.
- learn software to date, standardize and analyze tree rings.
- get hands-on experience based on the demonstration of wood (increment cores, stem discs, wedges), sampling in the field, and measuring and dating of tree rings in the tree-ring lab.
- solve R-based exercises (R tutorial will be provided) and answer questions in Moodle.
- work out an independent research question related to a dendroecological topic and write a short literature review based on scientific papers.

Objective

- Overview and history of dendrochronology
- Principles of dendrochronology
- Formation and structure of wood and tree rings
- Wood anatomy and intra-seasonal tree-ring growth
- Continuous and discontinuous tree-ring characteristics
- Sampling and measuring of tree rings
- Crossdating methods (visual, skeleton plots, quantitative)
- Detrending and standardization of tree-ring series
- Development of tree-ring chronologies
- Water transport in trees
- Stable isotopes in tree rings
- Climate influences, climate-growth relationships, climate reconstructions
- Reconstruction of forest dynamics (regeneration, growth, competition, mortality)
- Disturbance ecology (fire, insects, blowdown)
- Application of tree-ring research in practice and in interdisciplinary research projects
- Field and lab day (date for one entire day or two half days will be searched together with the students in the beginning of the semester): discussion of different dendroecological questions in the forest: sampling of trees, insight into different tree-ring projects in the lab (Swiss Federal Institute for Forest, Snow and Landscape Research WSL)

Lecture notes

Lecture notes (in English) will be handed out in the class.

Literature

Literature lists will be handed out in the class.

Prerequisites / notice

Time schedule (total of 90 hours): There will be 12 lectures with each two hours (total of 24 hours presence) as well as a field and lab day (8 hours presence). In addition, the students are expected to put 18 hours into the preparation of the lectures as well as 18 hours for the exercises. 4 hours are reserved for the lab work and 18 hours for the project.

The class language is German and English, on request English only.

Requirements:
Basics of biology, ecology and forest ecology

Fostered competencies

Subject-specific Competencies
Concepts and Theories
Techniques and Technologies

Method-specific Competencies
Analytical Competencies
Problem-solving
Project Management

Number of participants limited to 30.

Waiting list will be deleted 13.09.2022.

The course communicates the basics of the programming language Python and gives a general introduction into the geoprocessing framework of ArcGIS. In addition various Python libraries (numpy, Scipy, GDAL, statsmodels, pandas, Jupyter Notebook) will be introduced which increase the functional range of the geoprocessing framework substantially.

The students learn the basics of geographic data processing based on the programming language Python and ArcGIS (arcpy). They get the ability to implement their own processing sequences and models for geoprocessing. The students are able to integrate open source libraries in their Python scripts and know how the libraries are applied to spatial datasets.

The course communicates a deepened understanding of the geoprocessing frameworks arcpy and covers basic language concepts of Python such as datatypes, control structures and functions. In addition the application of popular Python libraries in combination with spatial datasets will be shown.

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Number of participants limited to 30.

Waiting list will be deleted 13.09.2022.
Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umweltnaturwissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning

Number of participants is limited to 80.

Course registration starts on 31.08.2022. Priority is given to the target groups until 23.09.2022.

Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning mode

Objective
The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
- understand convolution and deep learning models
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Data preparation for running and validating machine learning models
- Get to know machine learning approaches including regression, random forest and neural network
- Model complexity and hyperparameters
- Model parameterization and loss
- Model evaluations and uncertainty
- Deep learning with convolutions

Literature
Building on existing data science resources
Math IV, VI (Statistics); R, Python; ESDS I

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I

401-0627-00L Smoothing and Nonparametric Regression with Examples

Starting with an overview of selected results from parametric inference, kernel smoothing will be introduced along with some asymptotic theory, optimal bandwidth selection, data driven algorithms and some special topics. Selected numerical examples will be used for motivation. The presented methods will also be applicable elsewhere.

Abstract
The students will learn about methods of kernel smoothing and application of concepts to data. The aim will be to build sufficient interest in the topic and intuition as well as the ability to implement the methods to various different datasets.

Objective
The students are able to
- select an appropriate model related to a research question and dataset
- describe the steps from data preparation to running and evaluating models
- prepare data for running machine learning with dependent and independent variable
- build and validate regressions and neural network models
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Content
- The data science workflow
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Literature
Building on existing data science resources
Math IV, VI (Statistics); R, Python; ESDS I

Prerequisites / notice
Math IV, VI (Statistics); R, Python; ESDS I
Rough Outline:

- Parametric estimation methods: selection of important results
  o Method of Least squares: regression & diagnostics
- Nonparametric curve estimation
  o Density estimation, Kernel regression, Local polynomials, Bandwidth selection, various theoretical results related to consistency
  o Selection of special topics (as time permits, we will discuss some of the following): rapid change points, mode estimation, partial linear models, probability and quantile curve estimation, etc.
- Applications: potential areas of applications will be discussed such as, change assessment, trend and surface estimation and others.

References:

- Statistical Inference, by S.D. Silvey, Chapman & Hall.
- Density Estimation, by B.W. Silverman, Chapman and Hall.
- Nonparametric Simple Regression, by J. Fox, Sage Publications.

Additional references will be given out in the lectures.

Prerequisites: A background in Linear Algebra, Calculus, Probability & Statistical Inference including Estimation and Testing.

Colloquium

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Major in Human Health, Nutrition and Environment

Public Health

The module Public Health is compulsory for all students in the major Human Health, Nutrition and Environment.

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The course evaluates food and food ingredients in relation to primary and secondary prevention of chronic diseases including diabetes, gastrointestinal diseases, kidney disease, cardiovascular disease, arthritis and food allergies. Students will be required to complete a Project on a selected current topic relating to functional culture development, application and claims. Project will involve information research and critical assessment to develop an opinion, developed in an oral presentation.

Students will be provided with copies of power point slides from lectures.

The course provides an overview about the following topics: Factors influencing consumer's food choice, food and health, attitudes towards dietary etiologies of chronic disease, traditional and functional foods, and for benefiting human health. The course will integrate basic knowledge in food microbiology, physiology, biochemistry, and technology.

To examine and understand the protective effect of foods and food ingredients in the maintenance of health and the prevention of chronic diseases, as well as the progression of complications of the chronic diseases.

This course will address selected and current topics targeting functional characterization and new applications of microorganisms in food and for promoting human health. Specialists from the Laboratory of Food Biotechnology, as well as invited speakers from the industry will contribute to different topics:

- Probiotics and Prebiotics: human gut microbiota, functional foods and microbial-based products for gastrointestinal health and functionality, diet-microbiota interactions, molecular mechanisms; challenges for the production and addition of probiotics to foods.
- Protective Cultures and Antimicrobial Metabolites for enhancing food quality and safety: antifungal cultures; bacteriocin-producing cultures (bacteriocins); long path from research to industry in the development of new protective cultures.
- Safety of food cultures and probiotics
- Industrial biotechnology of flavor and taste development
- Legal and protection issues related to functional foods

This lecture requires strong basics in microbiology.

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>752-2122-00L</td>
<td>Food and Consumer Behaviour</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>M. Siegrist, F. Michel</td>
</tr>
<tr>
<td>752-5103-00L</td>
<td>Functional Microorganisms in Foods</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>C. Lacroix, A. Geirnaert, A. Greppi</td>
</tr>
<tr>
<td>752-6101-00L</td>
<td>Dietary Etiologies of Chronic Disease</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. B. Zimmermann</td>
</tr>
</tbody>
</table>

Environment and Health

Nanostructured Materials Safety

Fundamentals in nanostructured material - living system interactions focusing on the main exposure routes, lung, gastrointestinal tract, skin and intravenous injection.

Understanding the potential side effects of nanomaterials in a context-specific way, enabling to evaluate nanomaterial safety and provide knowledge to design safer materials.

Handouts provided during the classes and references therein as well as primary literature as case studies will be posted to the course website.

No compulsory prerequisites, but prior completion of the courses "Introduction to Nutritional Science" and "Advanced Topics in Nutritional Science" is strongly advised.

<table>
<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>376-1353-00L</td>
<td>Nanostructured Materials Safety</td>
<td>W</td>
<td>2 credits</td>
<td>1V</td>
<td>P. Wick</td>
</tr>
</tbody>
</table>
Infectious Diseases

Number | Title | Type | ECTS | Hours | Lecturers
--- | --- | --- | --- | --- | ---
701-0263-01L | Seminar in Evolutionary Ecology of Infectious Diseases | W | 3 credits | 2G | R. R. Regös, S. Bonhoeffer

Abstract
Students of this course will discuss current topics from the field of infectious disease biology. From a list of publications, each student chooses some themes that he/she is going to explain and discuss with all other participants and under supervision. The actual topics will change from year to year corresponding to the progress and new results occurring in the field.

Objective
This is an advanced course that will require significant student participation. Students will learn how to evaluate and present scientific literature and trace the development of ideas related to understanding the ecology and evolutionary biology of infectious diseases.

Content
A core set of ~10 classic publications encompassing unifying themes in infectious disease ecology and evolution, such as virulence, resistance, metapopulations, networks, and competition will be presented and discussed. Pathogens will include bacteria, viruses and fungi. Hosts will include animals, plants and humans.

Lecture notes
Publications and class notes can be downloaded from a web page announced during the lecture.

Literature
Papers will be assigned and downloaded from a web page announced during the lecture.

701-1471-00L | Ecological Parasitology | W | 3 credits | 1V+1P | F. A. A. Feijen, J. Jokela, C. Vorburger

Number of participants limited to 20.
A minimum of 6 students is required that the course will take place.

Waiting list will be deleted on 30.09.2022.

Abstract
Course focuses on the ecology and evolution of macroparasites and their hosts. Through lectures and practical work, students learn about diversity and natural history of parasites, adaptations of parasites, ecology of host-parasite interactions, applied parasitology, and human macroparasites in the modern world.

Objective
1. Identify common macroparasites in invertebrates.
2. Understand ecological and evolutionary processes in host-parasite interactions.
3. Conduct parasitological research

Content
Lectures:
1. Diversity and natural history of parasites (i.e. systematic groups and life-cycles).
2. Adaptations of parasites (e.g. evolution of life-cycles, host manipulation).
3. Ecology of host-parasite interactions (e.g. parasite communities, effects of environmental changes).
4. Ecology and evolution of parasitoids and their applications in biocontrol
5. Human macroparasites (schistosomiasis, malaria)

Practical exercises:
1. Examination of parasites in molluscs (identification and examination of host exploitation strategies).
2. Examination of parasites in amphipods (identification and examination of effects on hosts).
3. Examination of parasitoids of aphids.

Prerequisites / notice
The three practicals will take place at the 04.10.2022, the 18.10.2022 and the 08.11.2022 at Eawag Dübendorf from 08:15 - 12:00. Note that each practical takes 2 hours longer than the weekly lecture.

701-1703-00L | Evolutionary Medicine for Infectious Diseases | W | 3 credits | 2G | A. Hall

Number of participants limited to 33.

Waiting list will be deleted 02.10.2022.

Abstract
This course explores infectious disease from both the host and pathogen perspective. Through short lectures, reading and active discussion, students will identify areas where evolutionary thinking can improve our understanding of infectious diseases and, ultimately, our ability to treat them effectively.

Objective
Students will learn to (i) identify evolutionary explanations for the origins and characteristics of infectious diseases in a range of organisms and (ii) evaluate ways of integrating evolutionary thinking into improved strategies for treating infections of humans and animals. This will incorporate principles that apply across any host-pathogen interaction, as well as system-specific mechanistic information, with particular emphasis on bacteria and viruses.

Content
We will cover several topics where evolutionary thinking is relevant to understanding or treating infectious diseases. This includes: (i) determinants of pathogen host range and virulence, (ii) dynamics of host-parasite coevolution, (iii) pathogen adaptation to evade or suppress immune responses, (iv) antiviral resistance, (v) evolution-proof medicine. For each topic there will be a short (~ 20 minutes) introductory lecture, before students independently research the primary literature and develop discussion points and questions, followed by interactive discussion in class.

Literature
The focus is on primary literature, but for some parts the following text books provide good background information:

Schmid Hempel 2011 Evolutionary Parasitology
Stearms & Medzhitov 2016 Evolutionary Medicine

Prerequisites / notice
A basic understanding of evolutionary biology, microbiology or parasitology will be advantageous but is not essential.


Abstract
This course provides a detailed understanding of
- development of T and B cells
- the dynamics of an immune response during acute and chronic infection
- mechanisms of immunopathology
- modern vaccination strategies

Key experimental results will be shown to help understanding how immunological text book knowledge has evolved.
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common

Objectives
- Development and selection of CD4 and CD8 T cells, natural killer T cells (NKT), and regulatory T cells (Treg)
- NK T cells and responses to lipid antigens
- Differentiation, characterization, and function of CD4 T cell subsets such as Th1, Th2, and Th17
- Overview of cytokines and their effector function
- Co-stimulation (signals 1-3)
- Dendritic cells
- Evolution of the “Danger” concept
- Cells expressing Pattern Recognition Receptors and their downstream signals
- T cell function and dysfunction in acute and chronic viral infections

Literature
Documents of the lectures are available for download at:
https://moodle-app2.let.ethz.ch/course/view.php?id=2581&notifitytington=1

Prerequisites / notice
Immunology I and II recommended but not compulsory

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<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract
The course offers detailed information on selected foodborne pathogens and toxin producing organisms; the focus lies on relevant molecular biological aspects of pathogenicity and virulence, as well as on the occurrence and survival of these organisms in foods.

Objective
Detailed and current status of research and insights into the molecular basis of foodborne diseases, with focus on interactions of the microorganism or the toxins they produce with the human system. Understanding as well as the relationship between specific types of food and the associated pathogens and microbial risks. Another focus lies on the currently available methods and techniques useful for the various purposes, i.e., detection, differentiation (typing), and antimicrobial agents.

Content
Molecular biology of infectious foodborne pathogens (Listeria, E. coli, Campylobacter, Salmonella, etc) and toxin-producing organisms (Bacillus, Clostridium, Staphylococcus). How and under which conditions will toxins and virulence factors be produced, and how do they work? How is the interaction between the human host and the microbial pathogen? What are the roles of food and the environment? What can be done to interfere with the potential risks? Which methods are best suited for what approach? Last, but not least, the role of bacteriophages in microbial pathogenicity will be highlighted, in addition to various applications of bacteriophage for both diagnostics and antimicrobial intervention.

Lecture notes
Electronic copies of the presentation slides (PDF) and additional material will be made available for download to registered students.

Literature
Recommendations will be given in the first lecture

Prerequisites / notice
Lectures (2 hours) will be held as a single session of approximately 60+ minutes (10:15 until approx. 11:15 h), without a break!

Semester Paper and Seminar
The compulsory course 701-1701-00L Human Health, Nutrition and Environment: Term Paper is offered in the autumn semester only.

Electives

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-3001-00L</td>
<td>Environmental Systems Data Science: Data Processing</td>
<td>W</td>
<td>2</td>
<td>2G</td>
<td>L. Pellissier, E. J. Harris, J. Payne, M. Volpi</td>
</tr>
</tbody>
</table>

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.
Objective The students are able to
● frame a data science problem and build a hypothesis
● describe the steps of a typical data science project workflow
● conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
● critically think about the limits and implications of a method
● visualise data and results throughout the workflow
● access online resources to keep up with the latest data science methodology and deepen their understanding

Content
● The data science workflow
● Access and handle (large) datasets
● Prepare and clean data
● Analysis: data exploratory steps
● Analysis: machine learning and computational methods
● Evaluate results and analyse uncertainty
● Visualisation and communication

Prerequisites / notice
252-0840-02L Anwendungsnahes Programmieren mit Python
401-0624-00L Mathematik IV: Statistik
401-6215-00L Using R for Data Analysis and Graphics (Part I)
401-6217-00L Using R for Data Analysis and Graphics (Part II)
701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt Naturwissenschaften

701-3003-00L Environmental Systems Data Science: Machine Learning
Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022,
Target groups
Agricultural Sciences MSc
Environmental Sciences MSc
Atmospheric and Climate Science MSc
Environmental Sciences PhD
Agricultural Sciences PhD

Abstract Students are introduced to advanced data science where environmental data are analyzed using state of the art machine learning methods. Starting from known statistical approaches, they learn the principle of more advanced machine learning methods with practical application. The course enables students to plan their own data science project in their specialization and to apply machine learning methods

Objective The students are able to
• select an appropriate model related to a research question and dataset
• describe the steps from data preparation to running and evaluating models
• prepare data for running machine learning with dependent and independent variable
• build and validate regressions and neural network models
• understand convolution and deep learning models
• access online resources to keep up with the latest data science methodology and deepen their understanding

Content
• The data science workflow
• Data preparation for running and validating machine learning models
• Get to know machine learning approaches including regression, random forest and neural network
• Model complexity and hyperparameters
• Model parameterization and loss
• Model evaluations and uncertainty
• Deep learning with convolutions

Literature Building on existing data science resources

Prerequisites / notice Math IV, VI (Statistics); R, Python; ESDS I

▶ Minors

► Minor in Sustainable Energy Use

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<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>701-0967-00L</td>
<td>Project Development in Renewable Energies</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>R. Rechsteiner, A. Appenzeller</td>
</tr>
</tbody>
</table>

Number of participants limited to 30.

Waiting list will be deleted 05.10.2022.

Abstract Realization of projects in the field of renewable energies, analysis of legal frame conditions and risks.
The students learn basics of renewable energy project realization from acknowledged experts active in the field. They identify different tasks of various investor types. They develop sample projects in practice within groups

Objective You will receive a practice-oriented introduction to the regulatory, legal and business requirements for renewable energy projects. The possibilities of integrating fluctuating energy production in an environment of volatile prices will be demonstrated. Exercises based on concrete project examples in groups.

You will recognize the opportunities and risks of new projects and develop strategies to secure them.

Content Business models for renewable energy projects
Introduction of market trends, market structure, technical trends and regulation in Switzerland and in the EU internal energy market
Necessary frame conditions for profitable projects
Project development samples and exercises in wind power, hydro power, photovoltaics
due diligence and country assessment.
Exact Program in German below
http://www.rechsteiner-basel.ch/index.php?id=27

Lecture notes PPT presentation will be distributed (in German)
### Literature

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<tr>
<th>Title</th>
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<td>Mit einer grünen Anlage schwarze Zahlen schreiben Link</td>
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<tr>
<td>Energiestrategie 2050 Faktenblätter des Bundes (PDF)</td>
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<td>IEA PVPS: TRENDS IN PHOTOVOLTAIC APPLICATIONS</td>
<td><a href="http://www.iea-pvps.org">http://www.iea-pvps.org</a></td>
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<td>Unterlagen Windkraft-Projekte</td>
<td><a href="https://www.bfe.admin.ch/bfe/de/home/versorgung/erneuerbare-energien/windenergie.html">https://www.bfe.admin.ch/bfe/de/home/versorgung/erneuerbare-energien/windenergie.html</a></td>
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<td>Leitfaden Eigenverbrauch/ZEV</td>
<td><a href="https://pubb.cb.admin.ch/de/publication/download/9329">https://pubb.cb.admin.ch/de/publication/download/9329</a></td>
</tr>
</tbody>
</table>

### Prerequisites / notice

**For group exercise and presentation reasons the number of participants is limited at 30 students.**

For exercises students build learning and presentational groups. Credit points are based on group performance.

**701-1346-00L** Carbon Mitigation  
**W 3 credits  2G  N. Gruber**

**Number of participants limited to 100**

- **Priority is given to the target groups:** Bachelor and Master Environmental Sciences and PHD Environmental Sciences until 20.09.2022.
- **Waiting list will be deleted 30.09.2022.**

**Abstract**

Future climate change can only be kept within reasonable bounds when CO2 emissions are drastically reduced. In this course, we will discuss a portfolio of options involving the alteration of natural carbon sinks and carbon sequestration. The course includes introductory lectures, presentations from guest speakers from industry and the public sector, and final presentations by the students.

**Objective**

The goal of this course is to investigate, as a group, a particular set of carbon mitigation/sequestration options and to evaluate their potential, their cost, and their consequences.

**Content**

From the large number of carbon sequestration/mitigation options, a few options will be selected and then investigated in detail by the students. The results of this research will then be presented to the other students, the involved faculty, and discussed in detail by the whole group.

**Lecture notes**

None

**Literature**

Will be identified based on the chosen topic.

**Exam:** No final exam. Pass/No-Pass is assigned based on the quality of the presentation and ensuing discussion.

---

**052-0609-00L** Energy and Climate Design I  
**W 2 credits  2G  A. Schlüter**

**Abstract**

This annual course focuses on physical principles, concepts and methods for the efficient and sustainable heating, cooling and ventilation of buildings. Interactions of energy and climate with architectural and urban design will be investigated.

**Objective**

At the end of this one-year course, students will be able to estimate the impact of energy and climate on a building. You will be able to independently apply the steps of an integrated design process to your own project and master selected tools from the A/S knowledge platform (https://moodle-app2.let.ethz.ch/course/view.php?id=11917). Future own designs can be supplemented and enriched with potentials from energy and climate analyses.

**Content**

Students work independently in groups on a series of tasks. With the help of digital tools, the steps of an integrated design process are played through in a case study. The obligatory group tasks are supported with short input presentations, lecture notes and feedback sessions. The following topics are covered in the first semester of this annual course:

1. Local potentials
2. Demand
3. Supply

**Lecture notes**

The slides of the lecture serve as lecture notes and are available as download.

**Literature**

A list of relevant literature is available at the chair.

**Exam**

This course can only be taken if Energy and Climate Design II is taken in the following semester, as the group work is connected and extends throughout the year.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Sensitivity to Diversity

Personal Competencies
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-direction and Self-management

227-0731-00L  Power Market I - Portfolio and Risk Management  W  6 credits  4G  D. Reichelt, G. A. Koeppel

Abstract
Portfolio and risk management in the electrical power business, Pan-European power market and trading, futures and forward contracts, hedging, options and derivatives, performance indicators for the risk management, modelling of physical assets, cross-border trading, ancillary services, balancing power market, Swiss market model.

Objective

Content
1. Pan-European power market and trading
   1.1. Power trading
   1.2. Development of the European power markets
   1.3. Energy economics
   1.4. Spot and OTC trading
   1.5. European energy exchange EEX

2. Market model
   2.1. Market place and organisation
   2.2. Balance groups / balancing energy
   2.3. Ancillary services
   2.4. Market for ancillary services
   2.5. Cross-border trading
   2.6. Capacity auctions

3. Portfolio and Risk management
   3.1. Portfolio management 1 (introduction)
   3.2. Forward and futures contracts
   3.3. Risk management 1 (m2m, VaR, hpfc, volatility, cVaR)
   3.4. Risk management 2 (PaR)
   3.5. Contract valuation (HPFC)
   3.6. Portfolio management 2

4. Energy & Finance I
   4.1. Options 1 basics
   4.2. Options 2 hedging with options
   4.3. Introduction to derivatives (swaps, cap, floor, collar)
   4.4. Financial modelling of physical assets
   4.5. Trading and hydro power
   4.6. Incentive regulation

Lecture notes
Handouts of the lecture

Prerequisites / notice
1 excursion per semester, 2 case studies, guest speakers for specific topics.

Course Moodle: https://moodle-app2.let.ethz.ch/enrol/index.php?id=11638

Minor in Physical Glaciology

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<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>101-0289-00L</td>
<td>Applied Glaciology</td>
<td>W</td>
<td>4</td>
<td>2G</td>
<td>D. Farinotti, A. Bauder, M. Werder</td>
</tr>
</tbody>
</table>

Abstract
The course transmits fundamental knowledge for treating applied glaciological problems. Topics include climate-glacier interactions, glacier ice flow, glacier hydrology, ice avalanches, and lake ice.

Objective
The objectives of the courses are to:
- learn about fundamental glaciological processes, including glacier mass balance, ice dynamics, and glacier-related hazards;
- apply the above knowledge to some case studies inspired by contract-works performed at ETH's Glaciology section;
- generate the own computer code to solve the above case studies, and interpret the results;
- understand, both in class and in the field, the practical relevance of glaciology, with a focus on the Swiss applications.

Content
The course will develop along the following outline:
- How glaciology became a scientific discipline
- Glaciology and hydropower
- Glacier mechanics and ice flow
- Gravitational glacier instabilities
- Glacier hydrology and glacier lake outbursts
- Lake ice and ice bearing capacity
- Field excursion to Jungfraujoch
- Discussion of the exercises performed during the semester

Lecture notes
Digital lecture handouts will be distributed prior to each class.

Literature
Links to relevant literature will be provided during the classes.

Prerequisites / notice
Completed BSc studies. Basic knowledge in computer scripting in any language (e.g., Python, R, Julia, Matlab, IDL, ...) will be advantageous for solving the exercises. The exercises will be performed in groups. A minimal level of fitness is required for the field excursion.
Seminar in Glaciology

**651-1581-00L**

**Abstract**
Introduction to classic and modern literature of research in Glaciology. Active participation is expected and participants are mentored by PhD students of Glaciology.

**Objective**
In-depth knowledge of selected topics of research in Glaciology. Introduction to different types of scientific presentation. Improve ability of the discussion of scientific topics.

**Content**
Selected topics of scientific research in Glaciology

**Lecture notes**
Copies/pdf of scientific papers will be distributed during the course (moodle interface)

**Prerequisites / notice**
Active participation is expected with presence at the sessions. Only a limited number of participants can be accepted. One of the following courses should be taken as preparation:
- 651-3561-00L Kryosphäre
- 101-0289-00L Applied Glaciology
- 651-4101-00L Physics of Glaciers

**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<td>Techniques and Technologies</td>
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<td>Method-specific Competencies</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Project Management</td>
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<td>Social Competencies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td></td>
<td>Self-presentation and Social Influence</td>
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<td>Sensitivity to Diversity</td>
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<tr>
<td>Personal Competencies</td>
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<td>Creative Thinking</td>
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<td>Integrity and Work Ethics</td>
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<td>Self-awareness and Self-reflection</td>
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<td></td>
<td>Self-direction and Self-management</td>
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Quantification and Modeling of the Cryosphere: Dynamic Processes (University of Zurich)

**651-4077-00L**

**Abstract**
Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

**Objective**
Knowledge of the most prominent climate-related geomorphological processes and phenomena in high-mountain regions, understanding of primary research challenges.

**Content**
Erosion and sedimentation by glaciers as a function of topography, englacial temperature, sediment balance, sliding and melt water runoff. Processes and landforms in regions of seasonal and perennial frost (frost weathering, rock falls, debris cones/talus, solifluction, permafrost creep/rock glaciers, debris flows).

**Lecture notes**
Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

**Prerequisites / notice**
Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes

Physics of Glaciers

**651-4101-00L**

**Abstract**
No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

**Objective**
Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

**Content**
Overview of the most important earth surface processes and landforms in cold regions (regions with glaciers and intense frost) with emphasis on high-mountain aspects. Discussion of present research challenges.

**Lecture notes**
Glacial and periglacial geomorphodynamics in high-mountain regions. Ca. 100 pages.

**Prerequisites / notice**
Basic knowledge about geomorphology and glaciers/permafrost from corresponding courses at ETH/UZH or from the related lecture notes
Abstract
Understanding glaciers and ice sheets with simple physical concepts. Topics include the reaction of glaciers to the climate, flow of glacier ice, temperature in glaciers and ice sheets, glacier hydrology, glacier seismology, basal motion and calving glaciers. A specific focus is the current development of the ice sheets of Greenland and Antarctica.

Objective
After the course the students are able understand and interpret measurements of ice flow, subglacial water pressure and ice temperature. They will have an understanding of glaciology-related physical concepts sufficient to understand most of the contemporary literature on the topic. The students will be well equipped to work on glacier-related problems by numerical modeling, remote sensing, and field work.

Content
The dynamics of glaciers and polar ice sheets is the key requisite to understand their history and their future evolution. We will take a closer look at ice deformation, basal motion, heat flow and glacier hydraulics. The specific dynamics of tide water and calving glaciers is investigated, as is the reaction of glaciers to changes in mass balance (and therefore climate).

Lecture notes
Will be provided on Moodle

Literature
A list of relevant literature is available on Moodle

High-school mathematics and physics knowledge required.

Minor in Catchment Management and Natural Hazards

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0565-00L</td>
<td>Principles of Natural Hazard Management</td>
<td>W</td>
<td>3 credits</td>
<td>4G</td>
<td>V. Griess, A. Mathys</td>
</tr>
</tbody>
</table>

Abstract
This course provides an overview of the main natural hazards and their importance in a national and international context. The probability, risk and implications of various natural hazards will be discussed, along with potential management options. The course consists of introductory lectures and exercises, seminars with guest lectures by experts, student-led topic discussions, and a field trip.

Objective
By the end of the course, students will be able to:

- explain the main natural hazards, their processes and their importance in different contexts.
- describe the likelihood, risk, and consequences of natural hazards and their management options.
- identify and discuss the development of natural hazards in the context of climate change.
- develop, formulate and present solutions to these challenges to a critical audience.

Literature
will be distributed and available on Moodle

101-1250-00L | Management of Hillslope and Channel Processes | W | 3 credits | 2V | D. Rickenmann |

Abstract

Objective
Ziel
To recognise and understand channel and hillslope processes and their interactions. To learn about methods of hazard analysis and of technical and bioengineering protection measures and their assessment. Determination of critical loads and design of protective structures. Assessment of spatial and future developments with and without protective measures.

Content
Inhalt

Lecture notes
see "Literatur"

Prerequisites / notice
Besonderes
Requirements:
- Essentials of Construction Analysis
- Hydraulics
- Geology and Petrography
- Soil Physics
- Soil Mechanics and Geotechnics

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Communication</td>
<td>Adaptability and Flexibility</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>Cooperation and Teamwork</td>
<td>Creative Thinking</td>
</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>Customer Orientation</td>
<td>Critical Thinking</td>
</tr>
<tr>
<td>Project Management</td>
<td>Self-presentation and Social Influence</td>
<td>Leadership and Responsibility</td>
<td>Integrity and Work Ethics</td>
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<td></td>
<td>Sensitivity to Diversity</td>
<td>Self-awareness and Self-reflection</td>
<td>Self-awareness and Self-management</td>
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<tr>
<td></td>
<td>Negotiation</td>
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<td></td>
</tr>
</tbody>
</table>

102-0293-00L | Hydrology | W | 3 credits | 2G | P. Burlando |

Abstract
The course introduces the students to engineering hydrology. It covers first physical hydrology, that is the description and the measurement of hydrological processes (precipitation, interception, evapotranspiration, runoff, erosion, and snow), and it introduces then the basic mathematical models of the single processes and of the rainfall-runoff transformation, thereby including flood analysis.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2292 of 2416
Objective

Know the main features of engineering hydrology. Apply methods to estimate hydrological variables for dimensioning hydraulic structures and managing water resources.

Content

The hydrological cycle: global water resources, water balance, space and time scales of hydrological processes.

Precipitation: mechanisms of precipitation formation, precipitation measurements, variability of precipitation in space and time, precipitation regimes, point/basin precipitation, isochetal method, Thiessen polygons, storm rainfall, design hyetograph.

Interception: measurement and estimation.

Evaporation and evapotranspiration: processes, measurement and estimation, potential and actual evapotranspiration, energy balance method, empirical methods.

Infiltration: measurement, Horton's equation, empirical and conceptual models, phi-index and percentage method, SCS-CN method.

Surface runoff and subsurface flow: Hortonian and Dunnian surface runoff, streamflow measurement, streamflow regimes, annual hydrograph, flood hydrograph analysis – baseflow separation, flow duration curve.

Basin characteristics: morphology, topographic and phreatic divide, hypsometric curve, slope, drainage density.

Rainfall-runoff models (R-R): rationale, linear model of rainfall-runoff transformation, concept of the instantaneous unit hydrograph (IUH), linear reservoir, Nash model.

Flood estimation methods: flood frequency analysis, deterministic methods, probabilistic methods (e.g. statistical regionalisation, indirect R-R methods for flood estimation, rational method).

Erosion and sediment transport: watershed scale erosion, soil erosion by water, estimation of surface erosion, sediment transport.

Literature


Prerequisites / notice

Knowledge of statistics is a prerequisite. The required theoretical background, which is needed for understanding part of the lectures and performing part of the assignments, may be summarised as follows:

- Elementary data processing: hydrological measurements and data, data visualisation (graphical representation and numerical parameters),
- Frequency analysis: hydrological data as random variables, return period, frequency factor, probability paper, probability distribution fitting, parametric and non-parametric tests, parameter estimation.

Lecture notes

The lecture notes as well as the lecture presentations and handouts may be downloaded from the website of the Chair of Hydrology and Water Resources Management.

651-3525-00L

Introduction to Engineering Geology

| W | 4 credits | 2V+1U | L. de Palézieux dit Falconnet, M. Ziegler |

Abstract

This introductory course starts from a description of the behavior and phenomena of soils and rocks under near surface loading conditions and their key geotechnical properties. Lab and field methods for the characterization of soils, rocks and rock masses are introduced. Finally practical aspects of ground engineering, including tunneling and landslide hazards are presented.

Objective

Understanding the basic geotechnical and geomechanical properties and processes of rocks and soils. Understanding the interaction of rock and soil masses with technical systems. Understanding the fundamentals of geological hazards.

Content


Lecture notes

Written course documentation available on moodle.

651-4088-03L

Physical Geography III (Geomorphology and Glaciology) (University of Zürich)

| W | 5 credits | 1V+1U | University lecturers |

Abstract

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student.

UZH Module Code: GEO231

Mind the enrolment deadlines at UZH:

https://www.uzh.ch/cmsssl/en/studies/application/deadline.s.html

Minor in Forest Engineering and Wood Products

To successfully complete this minor, KPs must be earned for the two required courses:

- 701-1645-00 Forest Operations (autumn semester) and
- 701-1544-00 Forest Access and Transportation (spring semester)
### 701-1645-00L Forest Operations

**Abstract**
The discipline of Forest operations is constantly challenged to find solutions for unique problems. Each forest site requires specific technological approaches and machinery based on given management goals and ecological and environmental circumstances. Various terrain types and soil conditions, harvesting costs and taking care of the workforce by creating safe working conditions are some of the aspects that need to be considered. This course aims to provide students with a comprehensive understanding of the field of forest operations.

**Objective**
In this course, students will learn to use a wide variety of approaches grounded in the natural sciences, engineering, and technology to develop solutions tailored to unique challenges from the field of forest operations.

After participating in this course, students will have acquired foundational knowledge of a wide variety of core elements in the field of forest operations:

- The course will provide students with the ability to describe and differentiate site and stand conditions from an engineering perspective.
- Students will gain an overview and good working knowledge of current technology used in forest operations in Switzerland and around the world.
- Students will acquire the ability to assess the strength and weaknesses of the most commonly used equipment and analyze their suitability for a given set of environmental, economic, and social factors.
- Students will be able to combine different types of technology to create an optimal harvesting system for a given task, and assess a given system for its task-specific suitability.
- Participants will be able to assess the sustainability and potential short- and long-term impacts of harvesting systems under ecological, economic, and social constraints.

**Content**
- **Introduction**
  - Historic overview
  - Scope of operation
  - Site and stand characteristics
- Timber harvesting
  - Logging methods
  - Felling methods
  - Motor-Manual felling methods
    - Falling and processing
  - Forest machine structure and function
  - Harvester Technology
    - Felling heads
    - Carriers for felling heads
  - Bunching
  - Mechanical processing
  - Loading equipment
  - Operating techniques
- Primary Transport Systems
  - Ground based
    - Common features
    - Skidder
    - Forwarder
    - Loader Forwarder
  - Cable yarding
    - Common features
    - Wire rope
    - Cable yarding systems
    - Operating techniques
  - Aerial
    - Common features
    - Operating techniques
- Winch-Assisted Harvesting Operations
  - Harvesting
  - Primary transport
- Loading Equipment
- Secondary transport
  - Truck configurations
  - Soil compaction and contamination
  - Riparian areas
- Forest Operations management
  - Ergonomics
  - Work Safety
  - Economic Aspects
  - Environmental impact assessment
  - Equipment selection
- Forest operations across the globe
  - New Zealand
  - North America
    - British Columbia, Canada
    - South-eastern U.S.A
- Specialized equipment for small scale forest operations
- Outlook into the future of forest operations

**Literature**
Published on Moodle

**Prerequisites / notice**
701-1544-00 Forest Access and Transportation

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### 101-0637-10L Wood Structure and Function

**Type** W

<table>
<thead>
<tr>
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<tr>
<td>701-1544-00L</td>
<td>Forest Access and Transportation</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>I. Burgert, G. von Arx</td>
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### Minor in Agricultural Plant Production and Environment

<table>
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<td>701-1343-00L</td>
<td>Soil-Plant Water Relations</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Carminati</td>
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<tr>
<td>751-3700-00L</td>
<td>Plant Ecophysiology</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>N. Buchmann, A. Walter</td>
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</tbody>
</table>

**Abstract**

The course Wood structure and function conveys basic knowledge on the microstructure of softwoods and hardwoods as well as general and species-specific relationships between growth processes, wood properties and wood function in the living tree.

**Objective**

Learning target is a fundamental understanding of the anatomy of wood and the related impact of endogenous and exogenous factors. The students can learn how to distinguish common central European wood species at the macroscopic and microscopic level. A deeper insight will be given by wood identification exercises for softwood species. Further, the students will gain insight into the relationships between tree growth and wood properties with a specific focus on the wood function in the living tree.

**Content**

In an introduction to wood anatomy, the general structural features of softwoods and hardwoods will be explained and factors of diversity and variability will be discussed. A specific focus is laid on common central European tree species with relevance in the wood sector, which will be studied in macro- and microstructural investigations. In the following, relationships between wood structure, properties and function in the living tree will be in the focus of the lectures. Topics covered are water transport, trends in wood anatomy within trees, environmental impact on wood anatomy, wood defects and their causes, tools to study wood properties over time, secondary changes in wood, and tree biomechanics.
Analytical Competencies

Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops.

Prerequisites / notice

Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.

Fostered competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies

Social Competencies
Communication

Personal Competencies
Critical Thinking
Self-direction and Self-management

Objective

Students will be able to understand and evaluate experimental design and data interpretation of on-going studies, be able to critically analyze published research results, practice to present and discuss results in the public, and gain a broad knowledge of recent research and current topics in agro- and forest ecosystem sciences.

Content

Research results in agro- and forest ecosystem sciences will be presented by experienced researchers as well as Ph.D. and graduate students. Citation classics as well as recent research results will be discussed. Topics will range from plant ecophysiology, biodiversity and biogeochemistry to management aspects in agro- and forest ecosystems.


HLPE. 2019. Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and transformation.

Critical Thinking

few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

This class conveys current topics and methods of agroecological and food systems research through selected case studies from ongoing research of the Sustainable Agroecosystems group. Students will be encouraged to develop critical thinking competencies, through individual and group work, on major agricultural and food system challenges and paths towards agricultural and food system transformation.

This course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

Prerequisites / notice

Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.

Fostered competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies

Social Competencies
Communication

Personal Competencies
Critical Thinking
Self-direction and Self-management

Objective

During this course, students learn to assess the potential of different minor or alternative crops compared to the dominant major crops based on their biological and agronomical features. Each student will assess and present a specific alternative crop of his or her choice based on information from scientific articles and Wikipedia. Wikipedia-entries will be generated.

Content

Few crops dominate the crop rotations worldwide. Following the goal of an increased agricultural biodiversity, species such as buckwheat but also medicinal plants might become more important in future. The biology, physiology, stress tolerance and central aspects of the value-added chain of the above-mentioned and of other alternative crops will be depicted.

Critical Thinking

Modern weed management comprises competent knowledge of weed biology, weed ecology, population dynamics, crop-weed-interactions and different measures to control weeds. Weeds are understood to be rather part of a habitat or a cropping system than just unwanted plants in crops. Accordingly, this knowledge will be imparted during the course and will be required to understand the mechanisms of integrated weed control strategies.

Prerequisites / notice

Prerequisites: Basic knowledge of plant ecophysiology, terrestrial ecology and management of agro- and forest ecosystems. Course will be taught in English.

Fostered competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies

Social Competencies
Cooperation and Teamwork

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

Objective

(1) Systematically analyse and discuss case studies from ongoing agroecological and food system research.
(2) Learn and experiment on methods for field and laboratory investigations in agroecology.
(3) Engage with positive and empowering frameworks that motivate critical reflection and action on the types of transformative responses needed to adapt and thrive within agricultural and food systems.
(4) Reflect critically on agricultural and food system transformation tools and methods from the perspective a food system stakeholder.
(5) Identify and describe institutions in the context of sustainable agricultural development (for Bachelor and Master thesis and internships).

Content

The course will address a wide range of agricultural and food system challenges (e.g. food security, climate change, soil degradation, etc.) in both temperate and tropical contexts, from building food system resilience through innovative measures, to addressing soil fertility and GHG emissions. A wide variety of case studies will be presented, covering different scales (e.g. value-chains, farm and soil management).

The class is complemented by a role-playing exercise on food system transformation. Students will gain an overview on institutions and actors' roles in the field of sustainable agricultural development. Throughout the exercise, students will learn to cooperate through a teamwork exercise and understand what is the role of each stakeholders in the food system in order to support a sustainable transformation.

Prerequisites / notice

Prior participation in the lecture Nachhaltige Agrarkosysteme I (Sustainable Agroecosystems I) 751-5000-00G (spring term) recommended.

Fostered competencies

Subject-specific Competencies
Concepts and Theories

Method-specific Competencies
Analytical Competencies

Social Competencies
Cooperation and Teamwork

Personal Competencies
Critical Thinking
Self-awareness and Self-reflection
Self-direction and Self-management

Minor in Environmental, Resource and Food Economics

Number: 363-0537-00L
Title: Resource and Environmental Economics
Type: W
ECTS: 3
Hours: 2G
Lecturers: L. Bretschger

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 2296 of 2416
Abstract

Relationship between economy and environment, market failures, external effects and public goods, contingent valuation, internalisation of externalities, economics of non-renewable resources, economics of renewable resources, environmental cost-benefit analysis, sustainability economics, and international resource and environmental problems.

Objective

A successful completion of the course will enable a thorough understanding of the basic questions and methods of resource and environmental economics and the ability to solve typical problems using appropriate tools consisting of concise verbal explanations, diagrams or mathematical expressions. Concrete goals are first of all the acquisition of knowledge about the main questions of resource and environmental economics and about the foundation of the theory with different normative concepts in terms of efficiency and fairness. Secondly, students should be able to deal with environmental externalities and internalisation through appropriate policies or private negotiations, including knowledge of the available policy instruments and their relative strengths and weaknesses. Thirdly, the course will allow for in-depth economic analysis of renewable and non-renewable resources, including the role of stock constraints, regeneration functions, market power, property rights and the impact of technology. A fourth objective is to successfully use the well-known tool of cost-benefit analysis for environmental policy problems, which requires knowledge of the benefits of an improved natural environment. The last two objectives of the course are the acquisition of sufficient knowledge about the economics of sustainability and the application of environmental economic theory and policy at international level, e.g. to the problem of climate change.

Content

The course covers all the interactions between the economy and the natural environment. It introduces and explains basic welfare concepts and market failure; external effects, public goods, and environmental policy; the measurement of externalities and contingent valuation; the economics of non-renewable resources, renewable resources, cost-benefit-analysis, sustainability concepts; international aspects of resource and environmental problems; selected examples and case studies. After a general introduction to resource and environmental economics, highlighting its importance and the main issues, the course explains the normative basis, utilitarianism, and fairness according to different principles. Pollution externalities are a deep core topic of the lecture. We explain the governmental internalisation of externalities as well as the private internalisation of externalities (Coase theorem). Furthermore, the issues of free rider problems and public goods, efficient levels of pollution, tax vs. permits, and command and control instruments add to a thorough analysis of environmental policy. Turning to resource supply, the lecture first looks at empirical data on non-renewable natural resources and then develops the optimal price development (Hotelling-rule). It deals with the effects of explorations, new technologies, and market power. When treating the renewable resources, we look at biological growth functions, optimal harvesting of renewable resources, and the overuse of open-access resources. A next topic is cost-benefit analysis with the environment, requiring measuring environmental benefits and measuring costs. In the chapter on sustainability, the course covers concepts of sustainability, conflicts with optimality, and indicators of sustainability. In a final chapter, we consider international environmental problems and in particular climate change and climate policy.

Literature

Objective
Teilnehmer des Kurses sollen am Ende der Vorlesung i) grundlegende Unternehmensentscheide strukturieren und analysieren können, ii) verschiedene Analyse- und Planungsinstrumente auf Fragestellungen der Produktionsplanung, Investition und Finanzierung an Beispielen anwenden zu können, iii) verschiedene Werkzeuge zur unternehmerischen Entscheidungsunterstützung anwenden können und iv) die Spezifika von Unternehmen in der Agrar- und Ernährungswirtschaft kennen.

Content
Die Vorlesung geht auf folgende Inhalte, mit spezifischen Anwendungen im Agrar- und Ernährungssektors ein:

Grundlagen und Ziele unternehmerischen Entscheidens
Kosten und Leistungsrechnung
Produktionstheorie
Produktionsprogrammplanung
Investitionsplanung und Finanzierung
Entscheidungen unter Unsicherheit und Risikomanagement

Lecture notes
Vorlesungsunterlagen werden im Laufe des Semesters zur Verfügung gestellt

Literature

751-1573-00L Dynamic Simulation in Agricultural and Regional Economics

Abstract
In this class, students learn the basics of system dynamics and its application to agricultural and regional economic questions. In the second half of the class, students develop their own simulation model, with which they evaluate potential interventions for improving the economic as well as the ecological sustainability of food systems.

Objective
- Students learn the basic theory and practice of dynamic simulation
- Students can develop, analyze and extend a dynamic simulation model and interpret its results.
- By applying the developed simulation model, students gain insights into food system issues. They also learn to recognize the benefits and pitfalls of dynamic simulation, both from a theoretical and an applied perspective.

Lecture notes
slides (will be provided during the class)

Literature
articles and papers (will be provided during the class)

751-2103-00L Socioeconomics of Agriculture

Objective
Students should be able to describe the dynamics of hierarchies, markets and cooperation in an agricultural context.

Content
Introduction to Sociology
Introduction to Socioeconomics
Agricultural Administration: Path dependencies and efficiency issues
Power in the Chain
The farming family
Occupational Choices
Consumption Choices
Locational Choices
Common Resource Management in Alpine Farming
Agricultural Cooperatives
Societal perceptions of agriculture
Perceptions of farming from within
Varieties of agricultural systems and policies

Lecture notes

Literature
see script

Prerequisites / notice
Basic economic knowledge is expected.

751-2105-00L Political Ecology of Food and Agriculture

Abstract
In this seminar, students are introduced to the multi-disciplinary field of political ecology to investigate human-environment relationships in food and agricultural systems.

Objective
- Being able to provide an overview of the multi-disciplinary field of political ecology for investigating the relationships of humans to our environment
- Learn to identify how power and interest influence social-ecological systems and to distinguish symptoms from systemic root causes
- Become enabled to analyse complex and sometimes distant human-ecology relationships choosing from a broad range of methods

Content
We will review common narratives in agri-food systems informed by a range of different theories and assisted by different analytical tools. For this purpose, we will start from different concepts of nature, power and interests, explore different ontologies and epistemologies through a set of topics such as hunger, obesity, agrobiodiversity and seeds, forests and deforestation, climate change and food production. Students will explain one concept in each course to the groups and practice their argumentative and writing skills in a final essay, applying the acquired tools to a topic of their choice. While specific inputs from external lecturers broaden our perspective, enough time for critical discussion and reflection will be granted.

Literature
Literaturelist provided on Moodle.

Moodle: https://moodle-app2.let.ethz.ch/mod/assign/view.php?id=756049
The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) They know the basics of how to design and implement a policy evaluation study. 3) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) They can critically assess the science-policy interface of policy evaluations.

The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.

<table>
<thead>
<tr>
<th>Lectures</th>
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<th>ECTS</th>
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</thead>
<tbody>
<tr>
<td>751-2903-00L</td>
<td>Evaluation of Agricultural Policies</td>
<td>W</td>
<td>3 credits</td>
<td>2G</td>
<td>R. Huber, R. Finger, C. Schader</td>
</tr>
<tr>
<td>701-0019-00L</td>
<td>Readings in Environmental Thinking</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>J. Ghazoul</td>
</tr>
</tbody>
</table>

**Abstract**

In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.

**Objective**

The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) Students can critically assess the science-policy interface of policy evaluations.

**Content**

The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.

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<td>3 credits</td>
<td>2S</td>
<td>J. Ghazoul</td>
</tr>
</tbody>
</table>

**Abstract**

In this course, students get an overview of agricultural policy evaluations and their societal and political relevance. They learn to understand and apply the principles of scientific based evaluations of agricultural policies.

**Objective**

The course has four major learning objectives: 1) Students know the conceptual background of evaluations and can relate concepts in agricultural economics to the evaluation of policies. 2) Students can transfer their methodological knowledge from other agricultural economics courses to the context of agricultural policy evaluations (econometrics, modelling etc.). They make hands-on experiences of methodological challenges. 4) Students can critically assess the science-policy interface of policy evaluations.

**Content**

The course consists of two blocks: First, students will learn the basics of how to design, implement and interpret agricultural policy evaluations. In this block, the conceptual embedding, the design and methodological tools as well as case studies are presented. Secondly, the students make hands-on experience using econometric and modelling tools in the context of agricultural policy evaluations. They apply their theoretical and empirical knowledge to Swiss case studies.

**Electives**

**Additional Electives**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0019-00L</td>
<td>Readings in Environmental Thinking</td>
<td>W</td>
<td>3 credits</td>
<td>2S</td>
<td>J. Ghazoul</td>
</tr>
</tbody>
</table>

**Abstract**

This course introduces students to foundational texts that led to the emergence of the environment as a subject of scientific importance, and shaped its relevance to society. Above all, the course seeks to give confidence and raise enthusiasm among students to read more widely around the broad subject of environmental sciences and management both during the course and beyond.

**Objective**

The course will provide students with opportunities to read, discuss, evaluate and interpret key texts that have shaped the environmental movement and, more specifically, the environmental sciences. Students will gain familiarity with the foundational texts, but also understand the historical context within which their academic and future professional work is based. More directly, the course will encourage debate and discussion of each text that is studied, from both the original context as well as the modern context. In so doing students will be forced to consider and justify the current societal relevance of their work.

**Content**

The course will be run as a book reading club. The first session will provide a short introduction as to how to explore a particular text (that is not a scientific paper) to identify the key points for discussion. Thereafter, in each week a text (typically a chapter from a book or a paper) considered to be seminal or foundational will be assigned by a course lecturer. The lecturer will introduce the selected text with a brief background of the historical and cultural context in which it was written, with some additional biographical information about the author. He/she will also briefly explain the justification for selecting the particular text.

The students will read the text, with two to four students (depending on class size) being assigned to present it at the next session. Presentation of the text requires the students to prepare by, for example:

- identifying the key points made within the text
- identifying issues of particular personal interest and resonance
- considering the impact of the text at the time of publication, and its importance now
- evaluating the text from the perspective of our current societal and environmental position

Such preparation would be supported by a mid-week tutorial discussion (about 1 hour) with the assigning lecturer.

These students will then present the text (for about 15 minutes) to the rest of the class during the scheduled class session, with the lecturer facilitating the subsequent class discussion (about 45 minutes). Towards the end of the session the presenting students will summarise the emerging points (5 minutes) and the lecturer will finish with a brief discussion of how valuable and interesting the text was (10 minutes). In the remaining 15 minutes the next text will be presented by the assigning lecturer for the following week.

**Literature**

The specific texts selected for discussion will vary, but examples include:

- Leopold (1949) A Sand County Almanach
- Carson (1962) Silent Spring
- Jared Diamond (2005) Collapse

Discussions might also encompass films or other forms of media and communication about nature.
The professional internship is a compulsory part of the Master’s degree programme and requires that each student complete 18 weeks.

Environmental Systems Data Science: Data Processing

**Students who have taken 701-3001-00L Environmental Systems Data Science in autumn semester 2020 or 21 are not allowed to take this lecture. The content is similar.**

Number of participants is limited to 80.

Course registration starts on 31.08.2022.
Priority is given to the target groups until 23.09.2022.

Target groups:
- Agricultural Sciences MSc
- Environmental Sciences MSc
- Atmospheric and Climate Science MSc
- Environmental Sciences PhD
- Agricultural Sciences PhD

Waiting list will be deleted on 30.09.2022

Abstract
Students are introduced to a typical data science workflow using various examples from environmental systems. They learn common methods and key aspects for each step through practical application. The course enables students to plan their own data science project in their specialization and to acquire more domain-specific methods independently or in further courses.

Objective
The students are able to
- frame a data science problem and build a hypothesis
- describe the steps of a typical data science project workflow
- conduct selected steps of a workflow on specifically prepared datasets, with a focus on choosing, fitting and evaluating appropriate algorithms and models
- critically think about the limits and implications of a method
- visualise data and results throughout the workflow
- access online resources to keep up with the latest data science methodology and deepen their understanding

Content
- The data science workflow
- Access and handle (large) datasets
- Prepare and clean data
- Analysis: data exploratory steps
- Analysis: machine learning and computational methods
- Evaluate results and analyse uncertainty
- Visualisation and communication

Prerequisites / notice
- 252-0840-02L Anwendungsnahe Programmieren mit Python
- 401-0624-00L Mathematik IV: Statistik
- 401-6215-00L Using R for Data Analysis and Graphics (Part I)
- 401-6217-00L Using R for Data Analysis and Graphics (Part II)
- 701-0105-00L Mathematik VI: Angewandte Statistik für Umwelt Naturwissenschaften

Course Catalogue of ETH Zurich

Professional Internship

Only for Environmental Sciences MSc.
Completion and enrollment for the course «Professional Internship» is only possible after admission requirements and all additional requirements are fulfilled.

Registration and recognition of professional internship via https://www.lehrbetrieb.ethz.ch/praxis
No registration in myStudies required. For more information: www.usys.ethz.ch/internship-envsc

Abstract
In the compulsory internship outside of ETH Zürich, the students in Environmental Sciences learn about how environmental issues are handled professionally through their own practical work and by applying the knowledge they acquired. They will analyse complex environmental problems on scientific, technical and social levels and develop solutions in conjunction with social actors.

Objective
During the internship, students will learn how to professionally handle environmental issues from the technical-scientific, planning, administrative, and/or advisory perspective through their own practical experiences. They should apply the knowledge acquired from their studies. Furthermore, students will deepen their understanding in terms of development and implementation of environmental-friendly solutions in an everyday work-routine. Through this experience, they will develop important professional competence. Moreover, the internship will show them possible professional fields and establish valuable contacts for starting their careers in the future.

Content
The professional internship is a compulsory part of the Master’s degree programme and requires that each student complete 18 weeks outside of ETH Zürich. It can be completed in Switzerland or abroad. The students choose the position of the internship themselves. The position needs to fulfil the aims and requirements of the compulsory internship.

Job positions for environmental scientists are available in the following areas: environmental consulting firms, engineering and planning offices, clean-tech companies, industrial and service companies, federal administration, administration of cantons and municipalities, organisations and associations as well as companies operating in education, higher education, and media in relation to environmental and sustainable themes. Generally, the internship is performed outside the realm of the university.

Lecture notes
Detailed instructions and templates on the compulsory internship can be found online on Moodle: https://moodle-app2.let.ethz.ch/course/view.php?id=15228

Further support is provided by the company catalogue with companies in Switzerland and abroad that offer internships according to possibilities or where professional internships have taken place so far: https://www.usys.ethz.ch/pa-internship-envsc


The students look for a placement themselves. In order for an internship to be recognised as compulsory professional internship, an internship agreement must be approved in advance by the Internship Coordinator.

Further information and support online https://moodle-app2.let.ethz.ch/course/view.php?id=15228
Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-1002-00L</td>
<td>Master's Thesis</td>
<td>O</td>
<td>30</td>
<td>64D</td>
<td>Lecturers</td>
</tr>
</tbody>
</table>

Only students who fulfill the following criteria are allowed to begin with their Master's thesis:

- The signed request for the Bachelor's Degree Certificate has been submitted or processed.
- At least 32 CP of coursework related to the major have been acquired.
- All additional requirements (as stated in the admissions decision), including any assessment repetitions, are fulfilled.

Additional information is posted on the following webpage: https://www.usys.ethz.ch/en/studies/environmental-sciences/master/thesis.html

Abstract

The study programme is completed by a Master's thesis. The Master's thesis is an independent, scientific work. A topic within the field of specialization is chosen. It lasts 6 months.

Objective

This component is designed to enable the students to explore how the course content can be applied to an actual scientific problem. The thesis also provides an opportunity for the students to exercise initiative and to demonstrate that they are capable of working independently and in a scientifically structured manner.

Course Units for Additional Admission Requirements

The courses below are only available for Master students with additional admission requirements.

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>

Abstract

Students understand basic microeconomics and macroeconomics problems and theories. They are able to argue along economic principles and to judge policy measures.

Objective

Upon successful completion of the course, you will be able to:

- Describe the basic microeconomic and macroeconomic problems and theories.
- Make economic arguments to a given topic.
- Evaluate economic measures.

Content

Households, firms, supply and demand: How are household preferences and consumption behavior formed? How does a household react to price changes? How are goods prices formed? At what prices are firms willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can governments influence the market?

Market failure: What happens when prices give wrong signals?

Labor market: How do supply and demand work in the labor market? What influences unemployment?

National Accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work, and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society.

Literature


Future Admission Requirements

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>406-0002-AAL</td>
<td>Physics I</td>
<td>E-</td>
<td>5</td>
<td>11R</td>
<td>A. Vaterlaus</td>
</tr>
</tbody>
</table>

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Introduction to the concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

Objective

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts in mechanics.
Mathematics I

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in the theory of heat and electricity.

Content


Chapters:

1, 2, 3, 4, 5, 6 (without: 6-5, 6-6, 6-8), 7, 8 (without 8-9), 9, 10 (without 10-10), 11 (without 11-7), 13 (without 13-13, 13-14), 14 (without 14-6).

Literature

see "Content"

Friedhelm Kuypers

Physik für Ingenieure und Naturwissenschaftler

Band 1: Mechanik und Thermodynamik

Wiley-VCH Verlag, 2002, 544 S, ca.: Fr. 68.-

406-0064-AAL

Mathematics I and II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Concepts and tools in physics: mechanics of point-like and rigid bodies, elasticity theory, elements of hydrostatics and hydrodynamics, periodic motion and mechanical waves.

The "way of thinking" and the methodology in Physics. Magnetism, Refraction and Diffraction of Waves, Elements of Quantum Mechanics with applications to Spectroscopy, Thermodynamics, Phase Transitions, Transport Phenomena.

Objective

Introduction to the scientific methodology. The student should develop his/her capability to turn physical observations into mathematical models, and to solve the latter.

The student should acquire an overview over the basic concepts used in mechanics, in the theory of heat and electricity.

Content


Chapters:


Lecture see "Content"

Friedhelm Kuypers

Physik für Ingenieure und Naturwissenschaftler

Band 2 Elektrizität, Optik, Wellen

Verlag Wiley-VCH, 2003, Fr. 77.-

406-0064-AAL

Mathematics I and II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations.

Objective

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.
## Mathematics I & II

**Content**

1. Linear Algebra and Complex Numbers:
   - systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

2. Single-Variable Calculus:
   - review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

3. Ordinary Differential Equations:
   - separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

**Literature**

- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

**Prerequisites / notice**

Prerequisites: familiarity with the basic notions from Calculus, in particular those of function, derivative and integral.

**Assistance:**

Tuesdays and Wednesdays 17-18h, in Room HG E 41.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Lecturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>406-0252-AAL</td>
<td>Mathematics II</td>
<td>13 credits</td>
<td>28R</td>
</tr>
</tbody>
</table>

### 406-0252-AAL (Mathematics II)

**Abstract**

Continuation of the topics of Mathematics I, with main focus on multivariable calculus.

**Objective**

Mathematics is of ever increasing importance to the Natural Sciences and Engineering. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems (often with the help of high level mathematical software packages) and the interpretation of the results in the original environment.

The goal of Mathematics I and II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of these courses.

**Content**

- Multivariable Differential Calculus:
  - functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.

- Multivariable Integral Calculus:
  - multiple integrals, line and surface integrals, work and flux, Green, Gauss and Stokes theorems, applications.

**Literature**

- Thomas, G. B.: Thomas’ Calculus, Parts 2 (Pearson Addison-Wesley).

### 406-0253-AAL (Mathematics I & II)

**Content**

1. Linear Algebra and Complex Numbers:
   - systems of linear equations, Gauss-Jordan elimination, matrices, determinants, eigenvalues and eigenvectors, cartesian and polar forms for complex numbers, complex powers, complex roots, fundamental theorem of algebra.

2. Single-Variable Calculus:
   - review of differentiation, linearisation, Taylor polynomials, maxima and minima, antiderivative, fundamental theorem of calculus, integration methods, improper integrals.

3. Ordinary Differential Equations:
   - separable ordinary differential equations (ODEs), integration by substitution, 1st and 2nd order linear ODEs, homogeneous systems of linear ODEs with constant coefficients, introduction to 2-dimensional dynamical systems.

4. Multivariable Differential Calculus:
   - functions of several variables, partial differentiation, curves and surfaces in space, scalar and vector fields, gradient, curl and divergence.

5. Multivariable Integral Calculus:
   - multiple integrals, line and surface integrals, work and flow, Green, Gauss and Stokes theorems, applications.

**Literature**

- Bretscher, O.: Linear Algebra with Applications (Pearson Prentice Hall).

**Prerequisites / notice**

Prerequisites: familiarity with the basic notions from Calculus, in particular those of function, derivative and integral.

**Assistance:**

Tuesdays and Wednesdays 17-18h, in Room HG E 41.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>406-0603-AAL</td>
<td>Stochastics (Probability and Statistics)</td>
<td>4 credits</td>
</tr>
</tbody>
</table>

### 406-0603-AAL (Stochastics)

**Abstract**

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.
Abstract
Introduction to basic methods and fundamental concepts of statistics and probability theory for non-mathematicians. The concepts are presented on the basis of some descriptive examples. Learning the statistical program R for applying the acquired concepts will be a central theme.

Objective
The objective of this course is to build a solid fundament in probability and statistics. The student should understand some fundamental concepts and be able to apply these concepts to applications in the real world. Furthermore, the student should have a basic knowledge of the statistical programming language "R".

Content
From "Statistics for research" (online)
Ch 1: The Role of Statistics
Ch 2: Populations, Samples, and Probability Distributions
Ch 3: Binomial Distributions
Ch 6: Sampling Distribution of Averages
Ch 7: Normal Distributions
Ch 8: Student's t Distribution
Ch 9: Distributions of Two Variables

From "Introductory Statistics with R (online)"
Ch 1: Basics
Ch 2: The R Environment
Ch 3: Probability and distributions
Ch 4: Descriptive statistics and tables
Ch 5: One- and two-sample tests
Ch 6: Regression and correlation

Literature
- "Statistics for research" by S. Dowdy et. al. (3rd edition); Print ISBN: 9780471267355; Online ISBN: 9780471477433; DOI: 10.1002/0471477435
From within the ETH, this book is freely available online under: http://onlinelibrary.wiley.com/book/10.1002/0471477435

From within the ETH, this book is freely available online under: http://www.springerlink.com/content/m17578/

Fostered competencies
Subject-specific Competencies: Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies: Analytical Competencies assessed
Media and Digital Technologies assessed
Problem-solving assessed
Personal Competencies: Self-direction and Self-management assessed

529-2001-AAL Chemistry I and II E- 9 credits 19R J. Cvengros

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Chemistry I and II: Chemical bond and molecular structure, chemical thermodynamics, chemical equilibrium, kinetics, acids and bases, electrochemistry

Objective
Introduction to general and inorganic chemistry. Basics of the composition and the change of the material world. Introduction to the thermodynamically controlled physico-chemical processes. Macroscopic phenomena and their explanation through atomic and molecular properties. Using the theories to solve qualitatively and quantitatively chemical and ecologically relevant problems.

Content
1. Stoichiometry
2. Atoms and Elements (Quantenmechanical Model of the Atom)
3. Chemical Bonding
4. Thermodynamics
5. Chemical Kinetics
6. Chemical Equilibrium (Acids and Bases, Solubility Equilibria)
7. Electrochemistry

Lecture notes
Nivaldo J. Tro
Chemistry - A molecular Approach (Pearson), Chapter 1-18

Literature
Housecroft and Constable, CHEMISTRY
Oxtoby, Gillis, Nachtrieb, MODERN CHEMISTRY
Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
</tr>
<tr>
<td></td>
<td>Decision-making</td>
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<tr>
<td></td>
<td>Media and Digital Technologies</td>
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</tr>
<tr>
<td></td>
<td>Problem-solving</td>
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</tr>
<tr>
<td></td>
<td>Project Management</td>
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Social Competencies

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<td>Cooperation and Teamwork</td>
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</tr>
<tr>
<td>Customer Orientation</td>
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</tr>
<tr>
<td>Leadership and Responsibility</td>
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</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>not assessed</td>
</tr>
<tr>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
</tr>
<tr>
<td>Negotiation</td>
<td>not assessed</td>
</tr>
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</table>

Personal Competencies

<table>
<thead>
<tr>
<th>Adaptability and Flexibility</th>
<th>not assessed</th>
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</thead>
<tbody>
<tr>
<td>Creative Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Critical Thinking</td>
<td>assessed</td>
</tr>
<tr>
<td>Integrity and Work Ethics</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
</tr>
<tr>
<td>Self-direction and Self-management</td>
<td>assessed</td>
</tr>
</tbody>
</table>

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529-0234-AAL Chemistry I

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Chemistry I: Chemical bonding and molecular structure, chemical thermodynamics and kinetics, chemical equilibrium.

Objective

Acquiring the basics for describing the structure, composition and transformations of the material world. Introduction to thermodynamically determined chemical-physical processes. Use modeling to show how macroscopic phenomena can be understood in terms of atomic and molecular properties. Applications of theory to qualitatively and quantitatively solve simple chemical and environmental problems.

Content

1. stoichiometry
2. atomic structure
4. basics of chemical thermodynamics
   - System and environment. Description of the state and changes of state of chemical systems.
5. first law
   - Internal energy, heat and work. Enthalpy and enthalpy of reaction. Standard thermodynamic conditions.
6. second law
   - Entropy. Entropy changes in the system and in the universe. Reaction entropy due to heat of reaction and due to changes in matter.
7. Gibbs energy and chemical potential.
   - Combination of the two main theorems. Reaction Gibbs energy.
8. chemical equilibrium
   - Mass activities in gases, condensed substances and dissolved species. Gibbs energy in the course of chemical reactions. Equilibrium constant.
9. acids and bases
10. dissolution and precipitation
    - Heterogeneous equilibria. Dissolution process and solubility constant. Speciation diagrams. The carbon dioxide-carbonate equilibrium in the environment.

Literature


529-2002-AAL Chemistry II

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Chemistry II: Redox reactions, chemistry of the elements, introduction to organic chemistry

Objective

Erweitern der allgemeinen Grundlagen und Erarbeiten einer Basis, um Prozesse in komplexeren Umweltystemen (Wasser / Luft / Boden) in ihrem zeitlichen und quantitativen Ablauf verstehen und beurteilen zu können.
Content

1. Redox reactions

2. Inorganic Chemistry
   Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronic structure of the elements.

3. Introduction to organic chemistry
   Description of the most important classes of compounds and of the functional groups. Principal reactivity of these functional groups.
   Stereochemistry.
   Reaction mechanisms: SN1- and SN2-reactions, electrophilic aromatic substitutions, eliminations (E1 and E2), addition reactions (C=C and C=O double bonds), Chemistry of carboxylic and carboxyl groups.
   Rules for nomenclature of inorganic compounds. Systematic description of the groups of elements in the periodical system and the most important compounds of these elements. Formation of compounds as a consequence of the electronic structure of the elements.

Lecture notes

Literature


Abstract
Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

Objective
The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

Content
The first semester focuses on the organismal biology aspects of genetics, evolution and diversity of life in the Campbell chapters 12-34.

Week 1-7 by Alex Widmer, Chapters 12-25
12 Cell biology Mitosis
13 Genetics Sexual life cycles and meiosis
14 Genetics Mendelian genetics
15 Genetics Linkage and chromosomes
20 Genetics Evolution of genomes
21 Evolution How evolution works
22 Evolution Phylogentic reconstructions
23 Evolution Microevolution
24 Evolution Species and speciation
25 Evolution Macroevolution

Week 8-14 by Oliver Martin, Chapters 26-34
26 Diversity of Life Introduction to viruses
27 Diversity of Life Prokaryotes
28 Diversity of Life Origin & evolution of eukaryotes
29 Diversity of Life Nonvascular/seedless vascular plants
30 Diversity of Life Seed plants
31 Diversity of Life Introduction to fungi
32 Diversity of Life Overview of animal diversity
33 Diversity of Life Introduction to invertebrates
34 Diversity of Life Origin & evolution of vertebrates

Lecture notes
No script

Literature
Prerequisites / notice
This is a virtual self-study lecture for non-german speakers of the "Allgemeine Biology I (551-0001-00L) lecture. The exam will be written jointly with the participants of this lecture.

Example exam questions will be discussed during the lectures, and old exam questions are kept by the various student organisations. If necessary, please contact Prof. Uwe Sauer (sauer@ethz.ch) for details regarding the exam.

551-0003-AAL General Biology I+II
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
General Biology I: Organismic biology to teach the basic principles of classical and molecular genetics, evolutionary biology and phylogeny.

General Biology II: Molecular biology approach to teach the basic principles of biochemistry, cell biology, cgenetics, evolutionary biology and form and function of vascular plants.

Objective
General Biology I: The understanding of basic principles of biology (inheritance, evolution and phylogeny) and an overview of the diversity of life.

General Biology II: The understanding basic concepts of biology: the hierarchy of the structural levels of biological organisation, with particular emphasis on the cell and its molecular functions, the fundamentals of metabolism and molecular genetics, as well as form and function of vascular plants.

Content
General Biology I:

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-7</td>
<td>Alex Widmer, Chapters 12-25</td>
</tr>
<tr>
<td>12</td>
<td>Cell biology Mitosis</td>
</tr>
<tr>
<td>13</td>
<td>Genetics Sexual life cycles and meiosis</td>
</tr>
<tr>
<td>14</td>
<td>Genetics Mendelian genetics</td>
</tr>
<tr>
<td>15</td>
<td>Genetics Linkage and chromosomes</td>
</tr>
<tr>
<td>20</td>
<td>Genetics Evolution of genomes</td>
</tr>
<tr>
<td>21</td>
<td>Evolution How evolution works</td>
</tr>
<tr>
<td>22</td>
<td>Evolution Phylogentic reconstructions</td>
</tr>
<tr>
<td>23</td>
<td>Evolution Microevolution</td>
</tr>
<tr>
<td>24</td>
<td>Evolution Species and speciation</td>
</tr>
<tr>
<td>25</td>
<td>Evolution Macroevolution</td>
</tr>
</tbody>
</table>

Week 8-14 by Oliver Martin, Chapters 26-34

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Diversity of Life Introduction to viruses</td>
</tr>
<tr>
<td>27</td>
<td>Diversity of Life Prokaryotes</td>
</tr>
<tr>
<td>28</td>
<td>Diversity of Life Origin &amp; evolution of eukaryotes</td>
</tr>
<tr>
<td>29</td>
<td>Diversity of Life Nonvascular&amp;seedless vascular plants</td>
</tr>
<tr>
<td>30</td>
<td>Diversity of Life Seed plants</td>
</tr>
<tr>
<td>31</td>
<td>Diversity of Life Introduction to fungi</td>
</tr>
<tr>
<td>32</td>
<td>Diversity of Life Overview of animal diversity</td>
</tr>
<tr>
<td>33</td>
<td>Diversity of Life Introduction to invertebrates</td>
</tr>
<tr>
<td>34</td>
<td>Diversity of Life Origin &amp; evolution of vertebrates</td>
</tr>
</tbody>
</table>

General Biology II: The structure and function of biomacromolecules; basics of metabolism; tour of the cell; membrane structure and function; basic energetics of cellular processes; respiration, photosynthesis; cell cycle, from gene to protein; structure and growth of vascular plants, resource acquisition and transport, soil and plant nutrition.

Specifically the following Campbell chapters will be covered:

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Biochemistry Chemistry of water</td>
</tr>
<tr>
<td>4</td>
<td>Biochemistry Carbon: the basis of molecular diversity</td>
</tr>
<tr>
<td>5</td>
<td>Biochemistry Biological macromolecules and lipids</td>
</tr>
<tr>
<td>7</td>
<td>Cell biology Cell structure and function</td>
</tr>
<tr>
<td>8</td>
<td>Cell biology Cell membranes</td>
</tr>
<tr>
<td>10</td>
<td>Cell biology Respiration: introduction to metabolism</td>
</tr>
<tr>
<td>11</td>
<td>Cell biology Cell respiration</td>
</tr>
<tr>
<td>16</td>
<td>Genetics Nucleic acids and inheritance</td>
</tr>
<tr>
<td>17</td>
<td>Genetics Expression of genes</td>
</tr>
<tr>
<td>18</td>
<td>Genetics Control of gene expression</td>
</tr>
<tr>
<td>19</td>
<td>Genetics DNA Technology</td>
</tr>
<tr>
<td>35</td>
<td>Plant structure&amp;function Plant Structure and Growth</td>
</tr>
<tr>
<td>36</td>
<td>Plant structure&amp;function Transport in vascular plants</td>
</tr>
<tr>
<td>37</td>
<td>Plant structure&amp;function Plant nutrition</td>
</tr>
<tr>
<td>38</td>
<td>Plant structure&amp;function Reproduction of flowering plants</td>
</tr>
<tr>
<td>39</td>
<td>Plant structure&amp;function Plants signal and behavior</td>
</tr>
</tbody>
</table>

Lecture notes
No script

Literature

Prerequisites / notice
Basic general and organic chemistry

This is a virtual self-study lecture for non-German speakers of the "Allgemeine Biology I (551-0001-00L) and "Allgemeine Biology II (551-0002-00L) lectures. The exam will be written jointly with the participants of this lecture.

701-0023-AAL Atmosphere
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability, radiation, condensation, clouds, oxidation capacity and ozone layer.
Objective
Understanding of basic physical and chemical processes in the atmosphere. Understanding of mechanisms of and interactions between:
weather - climate, atmosphere - ocean - continents, troposphere - stratosphere. Understanding of environmentally relevant structures and
processes on vastly differing scales. Basis for the modelling of complex interrelations in the atmosphere.

Content
Basic principles of the atmosphere, physical structure and chemical composition, trace gases, atmospheric cycles, circulation, stability,
radiation, condensation, clouds, oxidation capacity and ozone layer.

Lecture notes
Written information will be supplied.

Literature
- John H. Seinfeld and Spyros N. Pandis, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, Wiley, New York,
1998.

701-0071-AAL
Mathematics III: Systems Analysis
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
The objective of the systems analysis course is to deepen and illustrate the mathematical concepts on the basis of a series of very
concrete examples. Topics covered include: linear box models with one or several variables, non-linear box models with one or several
variables, time-discrete models, and continuous models in time and space.

Objective
Learning and applying of concepts (models) and quantitative methods to address concrete problems of environmental relevance.
Understanding and applying the systems-analytic approach, i.e., Recognizing the core of the problem - simplification - quantitative
approach - prediction.

Content
Introduction to principles of models; one-dimensional linear box models; multi-dimensional linear box models; nonlinear box models;
models in space and time.

Lecture notes
Teaching material: book (see literature).

Literature
Springer Verlag.


701-0106-AAL
Mathematics V: Applied Deepening of Mathematics I - III
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Selected mathematical topics are presented for later use in more specialised lectures. Part of the topics were already discussed in the
lectures Mathematics I-III. Here, they should be shortly recapitulated and most importantly applied to practical problems. If necessary, new
mathematical concepts and methods will be introduced in order to solve challenging and inspiring problems from practice.

Objective
The aim of this lecture is to prepare the students for the more specialised lectures. They should become more familiar with the
mathematical background, the mathematical concepts and most of all with their application and interpretation.

Content
Practical examples from the following areas will be discussed: ordinary differential equations; eigenvalue problems from linear algebra;
systems of linear and nonlinear differential equations; partial differential equations (diffusion, transport, waves).

701-0243-AAL
Biology III: Essentials of Ecology
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This course assigns reading for students needing further background for understanding ecological processes. Central problems in ecology,
including population growth and regulation, the dynamics of species interactions, the influence of spatial structure, the controls over
species invasions, and community responses to environmental change will be explored from basic and applied perspectives.

Objective
Original language Students will understand how ecological processes operate in natural communities. They will appreciate how
mathematical theory, field experimentation, and observational studies combine to generate a predictive science of ecological processes.

 Upon completing the course, students will be able to:

Understand the factors determining the outcome of species interactions in communities, and how this information informs management.

Apply theoretical knowledge on species interactions to predict the potential outcomes of novel species introductions.

Understand the role of spatial structure in mediating population dynamics and persistence, species interactions, and patterns of species
diversity.

Use population and community models to predict the stability of interactions between predators and prey and between different
competitors.

Understand the conceptual basis of predictions concerning how ecological communities will respond to climate change.

Content
Readings from a text book will focus on understanding central processes in community ecology. Topics will include demographic and
spatial structure, consumer resource interactions, food webs, competition, invasion, and the maintenance of species diversity. Each of
these more conceptual topics will be discussed in concert with their applications to the conservation and management of species and
communities in a changing world.

701-0401-AAL
Hydrosphere
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
In this self-study course, students learn about relevant processes that control the water cycle on earth. Energy and mass exchange, mixing
and transport processes are described and the coupling of the hydrosphere with the atmosphere and the solid Earth are discussed.

Objective
Qualitative and quantitative understanding on how physical (and geochemical) processes control the natural dynamics in groundwater,
lakes ans oceans and constrain the exchange of mass and energy.
Content

Topics of the course.
Physical properties of water (i.e. density and equation of state)
- global water resources
Exchange at boundaries
- energy (thermal & kinetic), gas exchange
Mixing and transport processes in open waters
- vertical stratification, large scale transport
- turbulence and mixing
- mixing and exchange processes in rivers
Groundwater and its dynamics
- ground water as part of the terrestrial water cycle
- ground water hydraulics, Darcy's law
- aquifers and their properties
- hydrochemistry and tracer
- ground water use
Case studies
- 1. Water as resource, 2. Water and climate

Lecture notes

In addition to the self-learning literature handouts are distributed.

Literature

Textbooks for self-studying.
Surface water:
Chapter 4: Imboden, D.M., and Wüst, A. "Mixing Mechanisms in Lakes"
Chapter 6.4: Air-Water Partitioning
Chapter 19.2: Bottleneck Boundaries

Ground water:
Chapters 1 - 6, 8, 10, 11.

Optional additional readers.


701-0473-AAL Weather Systems E- 3 credits 6R M. A. Sprenger, F. Scholder-Aemisegger

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

The students learn about the dynamical features of the Earth's atmosphere. They interpret satellite imagery and learn about basic concepts in dynamical meteorology. The global circulation is briefly discussed, before introducing the Eulerian and the Lagrangian perspective, which are used to study air streams in extratropical cyclones and to investigate basic aspects in mountain meteorology.

Objective

The students are able to
- explain basic measurement and analysis techniques that are relevant in atmospheric dynamics
- to discuss the mathematical basics of atmospheric dynamics, based on selected atmospheric flow phenomena
- to explain the basic dynamics of the global circulation and of synoptic- and meso-scale flow features
- to explain how mountains influence the atmospheric flow on different scales
- basic understanding of the role of moist adiabatic processes for weather systems and why stable water isotopes are useful in this context

Content

Satellite observations; analysis of vertical soundings; geostrophic and thermal wind; cyclones at mid-latitude; global circulation; north- atlantic oscillation; atmospheric blocking situations; Eulerian and Lagrangian perspective; potential vorticity; Alpine dynamics (storms, orographic wind); planetary boundary layer

Lecture notes

Lecture notes and slides

Literature

Atmospheric Science, An Introductory Survey
John M. Wallace and Peter V. Hobbs, Academic Press

701-0475-AAL Atmospheric Physics E- 3 credits 6R F. Mahrt

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

This course covers the basics of atmospheric physics, which consist of: cloud and precipitation formation, thermodynamics, aerosol physics, radiation as well as the impact of aerosols and clouds on climate and artificial weather modification.

Objective

Students are able to
- to explain the mechanisms of cloud and precipitation formation using knowledge of humidity processes and thermodynamics.
- to evaluate the significance of clouds and aerosol particles for climate and artificial weather modification.

Content

Moist processes/thermodynamics; aerosol physics; cloud formation; precipitation processes, storms; importance of aerosols and clouds for climate and weather modification, clouds and precipitation

Lecture notes

Powerpoint slides and script will be made available

Literature


701-0501-AAL Pedosphere E- 3 credits 6R R. Kretzschmar

Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.

Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract

Introduction to the formation and properties of soils as a function of parent rock, landscape position, climate, and soil organisms. Complex relationships between soil forming processes, physical and chemical soil properties, soil biota, and ecological soil properties.

Objective

Understanding of soils as integral parts of ecosystems, development and distribution of soils as a function of environmental factors, and processes leading to soil degradation.
Definition of the pedosphere, soil functions, rocks as parent materials, minerals and weathering, soil organic matter, physical soil properties and functions, chemical soil properties and functions, soil formation, principles of soil classification, global soil regions, soil fertility, land use and soil degradation.

Literature

Prerequisites / notice
Prerequisites: Basic knowledge in chemistry, biology and geology.

Fostered competencies
<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Concepts and Theories</th>
<th>assessed</th>
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<tr>
<td></td>
<td>Techniques and Technologies</td>
<td>assessed</td>
</tr>
<tr>
<td>Method-specific Competencies</td>
<td>Analytical Competencies</td>
<td>assessed</td>
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<tr>
<td></td>
<td>Problem-solving</td>
<td>assessed</td>
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</tbody>
</table>

701-0721-AAL Psychology
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
This self-study course is an introductory course in psychology. This course will emphasize cognitive psychology and the psychological experiment.

Objective
Knowledge of key concepts and exemplary theories of psychology and their relation to "daily" psychology. Comprehension of relation between theory and experiment in psychology.

Goals: Learning how psychologists are thinking, a side change from the ETH natural science perspective to psychological thinking.

Domains of psychology:
- Psychology fields
- Concept definitions of psychology
- Theories of psychology
- Methods of psychology
- Results of psychology

Capability:
Be able to define a psychological research question
Basics understanding of role of psychology

Comprehension:
Psychology as a science of experience and behavior of the human

Content
Einführung in die psychologische Forschung und Modellbildung unter besonderer Berücksichtigung der kognitiven Psychologie und des psychologischen Experiments. Themen sind u.a.: Wahrnehmung; Lernen und Entwicklung; Denken und Problemlösen; Kognitive Sozialpsychologie; Risiko und Entscheidung.

Literature

Prerequisites / notice
Determine with Prof. Dr. Michael Siegrist the chapters in "Zimbardo" which are compulsory reading
Read the two Psychology chapters (6 + 7) from the book of Prof. Roland W. Scholz

752-4001-AAL Microbiology
Enrolment ONLY for MSc students with a decree declaring this course unit as an additional admission requirement.
Any other students (e.g. incoming exchange students, doctoral students) CANNOT enrol for this course unit.

Abstract
Self-study course in microbiology.

Objective
Teaching of basic knowledge in microbiology.

Content
This is a self-study course for students with microbiology as an admission requirement. The goal of the course is that students acquire basics in microbiology, including bacterial cell biology, genetics, growth and physiology, metabolism, phylogeny and microbial diversity, and applications of microbiology.

Literature
This self-study course is based on the book 'Brock, Biology of Microorganisms'.

Environmental Sciences Master - Key for Type

<table>
<thead>
<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Eligible for credits</td>
</tr>
<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
</tr>
</tbody>
</table>

| Z  | Courses outside the curriculum    |
| Dr | Suitable for doctorate           |
| O  | Compulsory                      |

Key for Hours
V  lecture
G  lecture with exercise
U  exercise
S  seminar
K  colloquium

P  practical/laboratory course
A  independent project
D  diploma thesis
R  revision course / private study

ECTS European Credit Transfer and Accumulation System
Special students and auditors need special permission from the lecturers.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2310 of 2416
This course gives an introduction into algorithms and numerical methods for parallel computing on shared and distributed memory architectures. The algorithms and methods are supported with problems that appear frequently in science and engineering.

With manufacturing processes reaching its limits in terms of transistor density on today’s computing architectures, efficient utilization of computing resources must include parallel execution to maintain scaling. The use of computers in academia, industry and society is a fundamental tool for problem solving today while the “think parallel” mind-set of developers is still lagging behind.

The aim of the course is to introduce the student to the fundamentals of parallel programming using shared and distributed memory programming models. The goal is on learning to apply these techniques with the help of examples frequently found in science and engineering and to deploy them on large scale high performance engineering (HPC) architectures.

1. Hardware and Architecture: Moore’s Law, Instruction set architectures (MIPS, RISC, CISC), Instruction pipelines, Caches, Flynn’s taxonomy, Vector instructions (for Intel x86)
2. Shared memory parallelism: Threads, Memory models, Cache coherency, Mutual exclusion, Uniform and Non-Uniform memory access, Open Multi-Processing (OpenMP)
3. Distributed memory parallelism: Message Passing Interface (MPI), Point-to-Point and collective communication, Blocking and non-blocking methods, Parallel file I/O, Hybrid programming models
4. Performance and parallel efficiency analysis: Performance analysis of algorithms, Roofline model, Amdahl’s Law, Strong and weak scaling analysis
5. Applications: HPC Math libraries, Linear Algebra and matrix/vector operations, Singular value decomposition, Neural Networks and linear autoencoders, Solving partial differential equations (PDEs) using grid-based and particle methods

Lecture notes:
https://www.cse-lab.ethz.ch/teaching/hpcse-i_hs22/

Class notes, handouts

Literature:
• An Introduction to Parallel Programming, P. Pacheco, Morgan Kaufmann
• Introduction to High Performance Computing for Scientists and Engineers, G. Hager and G. Wellein, CRC Press
• Computer Organization and Design, D.H. Patterson and J.L. Hennessy, Morgan Kaufmann
• Vortex Methods, G.H. Cottet and P. Koumoutsakos, Cambridge University Press
• Lecture notes

Prerequisites / notice: Students should be familiar with a compiled programming language (C, C++ or Fortran). Exercises and exams will be designed using C++.

The course will not teach basics of programming. Some familiarity using the command line is assumed. Students should also have a basic understanding of diffusion and advection processes, as well as their underlying partial differential equations.

Hydrodynamics and Cavitation

This course builds on the foundations of fluid dynamics to describe hydrodynamic flows and provides an introduction to cavitation.

The main learning objectives of this course are:
1. Identify and describe dominant effects in liquid fluid flows through physical modelling.
2. Identify hydrodynamic instabilities and discuss the stability region
3. Describe fragmentation of liquids
4. Explain tension, nucleation and phase-change in liquids.
5. Describe hydrodynamic cavitation and its consequences in physical terms.
6. Recognise experimental techniques and industrial and medical applications for cavitation.

The course gives an overview on the following topics: hydrostatics, capillarity, hydrodynamic instabilities, fragmentation. Tension in liquids, phase change. Cavitation: single bubbles (nucleation, dynamics, collapse), cavitating flows (attached, cloud, vortex cavitation). Industrial applications and measurement techniques.

Lecture notes:
Class notes, handouts

Literature:
Literature will be provided in the course material.

Prerequisites / notice: Fluid dynamics I & II or equivalent

Renewable Energy Technologies

Renewable energy technologies: solar PV, solar thermal, biomass, wind, geothermal, hydro, waste-to-energy. Focus is on the engineering aspects.

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

Lecture Notes containing copies of the presented slides.

Prerequisite: strong background on the fundamentals of engineering thermodynamics, equivalent to the material taught in the courses Thermodynamics I, II, and III of D-MAVT.

Fluid Dynamics with the Lattice Boltzmann Method

The course provides an introduction to theoretical foundations and practical usage of the Lattice Boltzmann Method for fluid dynamics simulations.

Methods like molecular dynamics, DSMC, lattice Boltzmann etc are being increasingly used by engineers all over and these methods require knowledge of kinetic theory and statistical mechanics which are traditionally not taught at engineering departments. The goal of this course is to give an introduction to ideas of kinetic theory and non-equilibrium thermodynamics with a focus on developing simulation algorithms and their realizations.

During the course, students will be able to develop a lattice Boltzmann code on their own. Practical issues about implementation and performance on parallel machines will be demonstrated hands on.

Central element of the course is the completion of a lattice Boltzmann code (using the framework specifically designed for this course).

The course will also include a review of topics of current interest in various fields of fluid dynamics, such as multiphase flows, reactive flows, microlows among others.

Optionally, we offer an opportunity to complete a project of student's choice as an alternative to the oral exam. Samples of projects completed by previous students will be made available.
The course builds upon three parts:
I Elementary kinetic theory and lattice Boltzmann simulations introduced on simple examples.
II Theoretical basis of statistical mechanics and kinetic equations.
III Lattice Boltzmann method for real-world applications.

The content of the course includes:

1. Background: Elements of statistical mechanics and kinetic theory:
   Particle's distribution function, Liouville equation, entropy, ensembles; Kinetic theory: Boltzmann equation for rarefied gas, H-theorem, hydrodynamic limit and derivation of Navier-Stokes equations, Chapman-Enskog method, Grad method, boundary conditions; mean-field interactions, Vlasov equation;
   Kinetic models: BGK model, generalized BGK model for mixtures, chemical reactions and other fluids.

2. Basics of the Lattice Boltzmann Method and Simulations:
   Minimal kinetic models: lattice Boltzmann method for single-component fluid, discretization of velocity space, time-space discretization, boundary conditions, forcing, thermal models, mixtures.

3. Hands on:
   Development of the basic lattice Boltzmann code and its validation on standard benchmarks (Taylor-Green vortex, lid-driven cavity flow etc).

4. Practical issues of LBM for fluid dynamics simulations:
   Lattice Boltzmann simulations of turbulent flows; numerical stability and accuracy.

5. Microrobots:
   Rarefaction effects in moderately dilute gases; Boundary conditions, exact solutions to Couette and Poiseuille flows; micro-channel simulations.

6. Advanced lattice Boltzmann methods:
   Entropic lattice Boltzmann scheme, subgrid simulations at high Reynolds numbers; Boundary conditions for complex geometries.

7. Introduction to LB models beyond hydrodynamics:
   Relativistic fluid dynamics; flows with phase transitions.

Lecture notes
Lecture notes on the theoretical parts of the course will be made available. Selected original and review papers are provided for some of the lectures on advanced topics. Handouts and basic code framework for implementation of the lattice Boltzmann models will be provided.

Prerequisites / notice
The course addresses mainly graduate students (MSc/Ph D) but BSc students can also attend.

151-0293-00L Combustion and Reactive Processes in Energy and Materials Technology

Abstract
This course will provide an introduction to the fundamentals and the applications of combustion in energy conversion and nanoparticles synthesis. The content is highly relevant for technologies which cannot be electrified such as long distance aviation and shipping, and which will more and more rely on carbon-neutral synthetic fuels.

Objective
The main learning objectives of this course are: 1. Understand the thermodynamic, fluid-dynamic and chemical kinetics fundamentals of combustion processes. 2. Predict relevant parameters for combustion systems, such as laminar and turbulent flame speeds, adiabatic flame temperature or quenching distance. 3. Understand the causal relations of relevant combustion parameters such as the pressure influence on the laminar flame speed. 4. Analyze the challenges of developing sustainable combustion technologies based on carbon-neutral synthetic fuels.

Content

Lecture notes
No script available. Instead, material will be provided in lecture slides and the following text book (which can be downloaded for free) will be followed:


Teaching language, assignments and lecture slides in English

Literature


151-0509-00L Acoustics in Fluid Media: From Robotics to Additive Manufacturing

Abstract
Note: The previous course title until HS21 "Microscale Acoustofluidics"
This course will provide you with the fundamentals of the new and exciting field of ultrasound-based microrobots to treat various diseases. Furthermore, we will explore how ultrasound can be used in additive manufacturing for tissue constructs and robotics.

Objective
The course is designed to equip students with skills in the design and development of ultrasound-based manipulation devices and microrobots for applications in medicine and additive manufacturing.

Content
Linear and nonlinear acoustics, foundations of fluid and solid mechanics and piezoelectricity, Gorkov potential, numerical modelling, acoustic streaming, applications from ultrasonic microrobots to surface acoustic wave devices

Lecture notes

Literature

Prerequisites / notice
Solid and fluid continuum mechanics. Notice: The exercise part is a mixture of presentation, lab sessions (both compulsory) and hand in homework.
Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

Concepts and Theories
Techniques and Technologies
Analytical Competencies
Decision-making
Media and Digital Technologies
Problem-solving
Project Management
Communication
Cooperation and Teamwork
Customer Orientation
Leadership and Responsibility
Self-presentation and Social Influence
Sensitivity to Diversity
Negotiation
Critical Thinking
Integrity and Work Ethics
Self-direction and Self-management

Micro- and Nanoparticle Technology
Number of participants is limited to 20.

Abstract
Particles are everywhere and nano is the new scale in science & engineering as micro was ~200 years ago. For highly motivated students, this exceptionally demanding class gives a flavor of nanotechnology with hands-on student projects on gas-phase particle synthesis & applications capitalizing on particle dynamics (diffusion, coagulation etc.), shape, size distribution and characterization.

Objective
This course aims to familiarize motivated M/BSc students with some of the basic phenomena of particles at the nanoscale, thereby illustrating the links between physics, chemistry, materials science through hands-on experience. Furthermore it aims to give an overview of the field with motivating lectures from industry and academia, including the development of technologies and processes based on particle technology with introduction to design methods of mechanical processes, scale-up laws and optimal use of materials and energy. Most importantly, this course aims to develop the creativity and sharpen the communication skills of motivated students through their individual projects, a PERFECT preparation for the M/BSc thesis (e.g. efficient & critical literature search, effective oral/written project presentations), the future profession itself and even life, in general, are always there!

Content
The course objectives are best met primarily through the individual student projects which may involve experiments, simulations or critical & quantitative reviews of the literature. Projects are conducted individually under the close supervision of MSc, PhD or post-doctoral students. Therein, a 2-page proposal is submitted within the first two semester weeks addressing explicitly, at least, 10 well-selected research articles and thoughtful meetings with the project supervisor. The proposal address 3 basic questions: a) how important is the project; b) what has been done already in that field and c) what will be done by the student. Detailed feedback on each proposal is given by the supervisor, assistant and professor two weeks later. Towards the end of the semester, a 10-minute oral presentation is given by the student followed by 10 minutes Q&A. A 10-page final report is submitted by noon of the last day of the semester. The project supervisor will provide guidance throughout the course. Lectures include some of the following:

- Overview & Project Presentation
- Particle Size Distribution
- Particle Diffusion
- Coagulation
- Agglomeration & Coalescence
- Particle Growth by Condensation
- Control of particle size & structure during gas-phase synthesis
- Multi-scale design of aerosol synthesis of particles
- Particle Characterization
- Aerosol manufacture of nanoparticles
- Forces acting on Single Particles in a Flow Field
- Fixed and Fluidized Beds
- Separations of Solid-Liquid & Solid-Gas systems
- Emulsions/droplet formation/microfluidics
- Gas Sensors
- Coaching for proposal & report writing as well as oral presentations

Additional ones could be enrolled by permission of the lecturer.

Literature

Prerequisites / notice
FluidMechanik I, Thermodynamik I & "clean" 5th semester BSc student standing in D-MAVT (no block 1 or 2 obligations). Students attending this course are expected to allocate sufficient additional time within their weekly schedule to successfully conduct their project. As exceptional effort will be required! Having seen “Chasing Mavericks” (2012) by Apted & Henson, “Unbroken” (2014) by Angelina Jolie and, in particular, “The Salt of the Earth” (2014) by Wim Wenders might be helpful and even motivating. These movies show how methodic effort can bring superior and truly unexpected results (e.g. stay under water for 5 minutes to overcome the fear of riding huge waves or merciless Olympic athlete training that help survive 45 days on a raft in Pacific Ocean followed by 2 years in a Japanese POW camp during WWII).

Medical Technology Innovation - From Concept to Clinics

Abstract
Project-oriented learning on how to develop technological solutions to address unmet clinical needs.

Objective
After completing the course, you will be able to effectively collaborate with medical doctors in order to identify important unmet clinical needs. You will be able to ideate and develop appropriate engineering solutions and implementation strategies for real-world clinical problems. This lecture aims to prepare you for typical engineering challenges in the real-world where - in addition to the development of an elegant solution - interdisciplinary team work and effective communication play a key role.

Lecture notes and Literature
will be available on the moodle.

Prerequisites / notice
On site presence during (most) of the lectures highly encouraged!
Graded innovation project will require on-site presence.
Introduction to Photonics

Abstract
This course introduces students to the main concepts of optics and photonics. Specifically, we will describe the laws obeyed by optical waves and discuss how to use them to manipulate light.

Objective
Photonics, the science of light, has become ubiquitous in our lives. Control and manipulation of light is what enables us to interact with the screen of our smart devices and exchange large amounts of complex information. Photonics has also taken a preponderant role in cutting-edge science, allowing for instance to image nanospecimens, detect diseases or sense very tiny forces. The purpose of this course is three-fold: (i) We first aim to provide the fundamentals of photonics, establishing a solid basis for more specialised courses. (ii) Beyond theoretical concepts, our intention is to have students develop an intuition on how to manipulate light in practice. (iii) Finally, the course highlights how the taught concepts apply to modern research as well as to everyday life technologies (LCD screens, polarisation sun glasses, anti-reflection coating etc...). Content, including videos of laboratory experiments, has been designed to be approachable by students from a diverse set of science and engineering backgrounds.
I- BASICS OF WAVE THEORY
1) General concepts
2) Differential wave equation
3) Wavefront
4) Plane waves and Fourier decomposition of optical fields
5) Spherical waves and Huygens-Fresnel principle

II- ELECTROMAGNETIC WAVES
1) Maxwell equations
2) Wave equation for EM waves
3) Dielectric permittivity
4) Refractive index
5) Nonlinear optics
6) Polariation and polarisation control

III- PROPAGATION OF LIGHT
1) Waves at an interface
2) The Fresnel equations
3) Total internal reflection
4) Evanescent waves
5) Dispersion diagram

IV- INTERFERENCES
1) General considerations
2) Temporal and spatial coherence
3) The Young double slit experiment
4) Diffraction gratings
5) The Michelson interferometer
6) Multi-wave interference
7) Antireflecting coating and interference filters
8) Optical holography

V- LIGHT MANIPULATION
1) Optical waveguides
2) Photonic crystals
3) Metamaterials and metasurfaces
4) Optical cavities

VI- INTRODUCTION TO OPTICAL MICROSCOPY
1) Basic concepts
2) Direct and Fourier imaging
3) Image formation
4) Fluorescence microscopy
5) Scattering-based microscopy
6) Digital holography
7) Computational imaging

VII- OPTICAL FORCES AND OPTICAL TWEEZERS
1) History of optical forces
2) Theory of optical trapping
3) Atom cooling
4) Optomechanics
5) Plasmonic trapping
6) Applications of optical tweezers

Abstract
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Objective
This course presents the fundamentals of transport phenomena with emphasis on mass transfer. The physical significance of basic principles is elucidated and quantitatively described. Furthermore the application of these principles to important engineering problems is demonstrated.

Content
Fick's laws; application and significance of mass transfer; comparison of Fick's laws with Newton's and Fourier's laws; derivation of Fick's 2nd law; diffusion in dilute and concentrated solutions; rotating disk; dispersion; diffusion coefficients, viscosity and heat conduction (Pr and Sc numbers); Brownian motion; Stokes-Einstein equation; mass transfer coefficients (Nu and Sh numbers); mass transfer across interfaces; Analogies for mass-, heat-, and momentum transfer in turbulent flows; film-, penetration-, and surface renewal theories; simultaneous mass, heat and momentum transfer (boundary layers); homogeneous and heterogeneous reversible and irreversible reactions; diffusion-controlled reactions; mass transfer and first order heterogeneous reaction. Applications.

Literature

Prerequisites / notice
Students attending this highly-demanding course are expected to allocate sufficient time within their weekly schedule to successfully conduct the exercises.
Literature
Recommendations for text books will be covered in the class.

Prerequisites / notice
Requirements (recommended, not mandatory): Thermal separation Processes I (151-0926-00) and Modelling and mathematical methods in process and chemical engineering (151-0940-00)

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Techniques and Technologies</td>
<td>Assessed</td>
<td>assessed</td>
</tr>
<tr>
<td>Analytical Competencies</td>
<td>Decision-making</td>
<td>not assessed</td>
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</tr>
<tr>
<td>Media and Digital Technologies</td>
<td>Problem-solving</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Project Management</td>
<td></td>
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<tr>
<td>Communication</td>
<td>Cooperation and Teamwork</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Customer Orientation</td>
<td>Leadership and Responsibility</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Self-presentation and Social Influence</td>
<td>Sensitivity to Diversity</td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Negotiation</td>
<td></td>
<td>not assessed</td>
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<tr>
<td>Adaptable and Flexibility</td>
<td></td>
<td>not assessed</td>
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<tr>
<td>Creative Thinking</td>
<td>Critical Thinking</td>
<td>assessed</td>
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<tr>
<td>Integrity and Work Ethics</td>
<td>Self-awareness and Self-reflection</td>
<td>not assessed</td>
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<tr>
<td>Self-direction and Self-management</td>
<td></td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Sensitivity to Diversity</td>
<td>Negotiation</td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Emotional Intelligence</td>
<td></td>
<td>not assessed</td>
<td></td>
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<tr>
<td>Negotiation</td>
<td></td>
<td>not assessed</td>
<td></td>
</tr>
<tr>
<td>Social Skills</td>
<td></td>
<td>not assessed</td>
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</tbody>
</table>

151-0951-00L Process Design and Safety W 4 credits 2V+1U F. Trachsel, C. Hutter

Abstract
The lecture Process Design and Safety deals with the fundamentals of project management, scale-up, dimensioning and safety of chemical process equipment and plants.

Objective
The objective of the lecture is to expound the engineering design approach of important elements in chemical plant design.

Content
- Fundamentals in Chemical engineering Design;
- Project Management;
- Cost estimate;
- Materials and Corrosion;
- Piping and Armatures;
- Pumps;
- Reactors and Scale-up;
- Safety of chemical processes, Patents.

Lecture notes
The lecture slides will be distributed.

Literature

Prerequisites / notice
A 1-day excursion including a visit of a chemical plant will be part of the lecture.

151-0957-00L Practica in Process Engineering I W 2 credits 2P S. A. Meyer, M. Tibbitt

Abstract
Practical training at pilot facilities for fundamental processing steps, typical laboratory and pilot facility experiments.

Objective
Getting acquainted with unit operations, measuring tools and data processing

Content
4 modules in total (3 from Prof. Norris, 1 from Prof. Mark Tibbitt)
Details and dates will be communicated at the beginning of the semester.

- Residence Time Distribution
- Tibbitt
- Perovskite Nanocrystals - Synthesis and Characterization
- Norris
- ICP Elemental Analysis
- Norris
- Scanning Electron Microscope Imaging (SEM)
- Norris

Lecture notes
Scripts of the specific practice will be available shortly before the modules.

Literature
Own scripts

529-0613-01L Process Simulation and Flowsheeting W 6 credits 3G G. Guillén Gosálbez

Abstract
This course encompasses the theoretical principles of chemical process simulation and optimization, as well as its practical application in process analysis. The techniques for simulating stationary and dynamic processes are presented, and illustrated with case studies. Commercial software packages (Aspen) are introduced for solving process flowsheeting and optimization problems.

Objective
This course aims to develop the competency of chemical engineers in process flowsheeting, process simulation and process optimization. Specifically, students will develop the following skills:
- Deep understanding of chemical engineering fundamentals: the acquisition of new concepts and the application of previous knowledge in the area of chemical process systems and their mechanisms are crucial to intelligently simulate and evaluate processes.
- Modeling of general chemical processes and systems: students should be able to identify the boundaries of the system to be studied and develop the set of relevant mathematical relations, which describe the process behavior.
- Mathematical reasoning and computational skills: the familiarization with mathematical algorithms and computational tools is essential to be capable of achieving rapid and reliable solutions to simulation and optimization problems. Hence, students will learn the mathematical principles necessary for process simulation and optimization, as well as the structure and application of process simulation software. Thus, they will be able to develop criteria to correctly use commercial software packages and critically evaluate their results.
- Process optimization: the students will learn how to formulate optimization problems in mathematical terms, the main type of optimization problems that exist (i.e., LP, NLP, MILP and MINLP) and the fundamentals of the optimization algorithms implemented in commercial solvers.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2316 of 2416
Content

Overview of process simulation and flowsheeting:
- Definition and fundamentals
- Fields of application
- Case studies

Process simulation:
- Modeling strategies of process systems
- Mass and energy balances and degrees of freedom of process units and process systems

Process flowsheeting:
- Flowsheet partitioning and tearing
- Solution methods for process flowsheeting
- Simultaneous methods
- Sequential methods

Process optimization and analysis:
- Classification of optimization problems
- Linear programming, LP
- Non-linear programming, NLP
- Mixed-integer linear programming, MILP
- Mixed-integer nonlinear programming, MINLP

Commercial software for simulation (Aspen Plus):
- Thermodynamic property methods
- Reaction and reactors
- Separation / columns
- Convergence, optimisation & debugging

Literature

An exemplary literature list is provided below:
- Smith, R. Chemical process design and integration, Wiley (2005).

Prerequisites / notice

A basic understanding of material and energy balances, thermodynamic property methods and typical unit operations (e.g., reactors, flash separations, distillation/absorption columns etc.) is required.

Multidisciplinary Courses

The students are free to choose individually Master's courses from the Course Catalogue of ETH Zurich, ETH Lausanne and the Universities of Zurich (https://www.uzh.ch/cmsssl/en/studies/application/chmobilityin.html) and St. Gallen.

Semester Project

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1008-00L</td>
<td>Semester Project Process Engineering Only for Process Engineering MSc</td>
<td>O</td>
<td>8 credits</td>
<td>17A</td>
<td>Professors</td>
</tr>
</tbody>
</table>

Abstract

The subject of the Master Thesis and the choice of the supervisor (ETH-professor) are to be approved in advance by the tutor.

Objective

The semester project is designed to train the students in the solution of specific engineering problems. This makes use of the technical and social skills acquired during the master's program. Tutors propose the subject of the project, elaborate the project plan, and define the roadmap together with their students, as well as monitor the overall execution.

Industrial Internship

<table>
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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>151-1090-00L</td>
<td>Industrial Internship Access to the company list and request for recognition under <a href="http://www.mavt.ethz.ch/praxis">www.mavt.ethz.ch/praxis</a>.</td>
<td>O</td>
<td>8 credits</td>
<td>external organisers</td>
<td></td>
</tr>
</tbody>
</table>

Abstract

No registration required via myStudies.

Objective

The main objective of the minimum twelve-week internship is to expose Master’s students to the industrial work environment. The aim of the Industrial Internship is to apply engineering knowledge to practical situations.

Science in Perspective

see Science in Perspective: Type A: Enhancement of Reflection Capability

Recommended Science in Perspective (Type B) for D-MAVT

see Science in Perspective: Language Courses ETH/UZH

Master's Thesis

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
</table>
Students who fulfill the following criteria are allowed to begin with their Master's Thesis:

- Successful completion of the bachelor program;
- Fulfilling of any additional requirements necessary to gain admission to the master programme;
- Successful completion of the semester project and industrial internship;
- Achievement of 28 ECTS in the category "Core Courses".

The Master's Thesis must be approved in advance by the tutor and is supervised by a professor of ETH Zurich.

Abstract

Students attend and give research presentations for the research they plan to do and at the end of the semester they defend their results and answer questions from research scientists. Familiarize the students with the latest in this field.

Objective

- Students attend and give research presentations for the research they plan to do.
- At the end of the semester, they defend their results and answer questions from research scientists.
- Students get insight into actual areas and problems of Biomedical Engineering and Health Care.

Process Engineering Master - Key for Type

- O: Compulsory
- W+: Eligible for credits and recommended
- W: Eligible for credits
- E-: Recommended, not eligible for credits
- Z: Courses outside the curriculum
- Dr: Suitable for doctorate

Key for Hours

- V: Lecture
- G: Lecture with exercise
- U: Exercise
- S: Seminar
- K: Colloquium
- P: Practical/laboratory course
- A: Independent project
- D: Diploma thesis
- R: Revision course / private study

ECOS: European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.
Science in Perspective

In “Science in Perspective”-courses students learn to reflect on ETH’s STEM subjects from the perspective of humanities, political and social sciences.

Only the courses listed below will be recognized as “Science in Perspective” courses.

➤ Type A: Enhancement of Reflection Competence

SiP courses are recommended for bachelor students after their first-year examination and for all master- or doctoral students. All SiP courses are listed in Type A.

Courses listed under Type B are only recommendations for enrollment for specific departments.

➤➤ History

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0725-00L</td>
<td>History Part One: Europe (The Cradle of Modernity, Britain, 1789-1914)</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>H. Fischer-Tiné</td>
</tr>
</tbody>
</table>

Abstract: A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series asks whether one single model of modernization prevailed on the ‘Old Continent’ or whether we need to differentiate regionally. A special focus lies on the Swiss experience.

Objective: At the end of this lecture course, students: (a) highlight the most important changes in the “long nineteenth century” in Europe (b) explain their long-term effects; and (c) relate these changes to global developments today.

Content: The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.

Lecture notes: Power Point Slides and references will be made available in digital form during the course of the semester.

Prerequisites / notice: This lecture series does not build upon specific previous knowledge by the students.

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<tr>
<th>Number</th>
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<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0725-00L</td>
<td>Background Knowledge Arabic World</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>U. Göskén</td>
</tr>
</tbody>
</table>

Abstract: This lecture will discuss important topics of the Arab culture involving concepts relating to history, the role of literature, sciences and religion, concepts of ‘the West’, meaning of education, understanding of culture as well as current concepts and discourses relevant at the sociocultural level.

Objective: Teaching about epistemic contents relating to the Arabic world that constitute modern Arabs’ self understanding and are relevant for adequate behavior in practically dealing with the Arabic world. What basic knowledge about ‘their’ culture are Arabs taught? What educational goals are pursued? What is the relationship they build with the West? What topics are discussed on the basis of a scientifically critical approach are concepts and understandings of history, the role of literature, sciences and religion, concepts of the West and relationship with the West, the role of education, understanding of culture and cultural refinement, current concepts and discourses relevant at the sociocultural level.

<table>
<thead>
<tr>
<th>Number</th>
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<th>Type</th>
<th>ECTS</th>
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<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0725-00L</td>
<td>Global History of Urban Design I</td>
<td>W</td>
<td>2 credits</td>
<td>2G</td>
<td>T. Avermaete</td>
</tr>
</tbody>
</table>

Abstract: This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

Objective: The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students’ future design work.

Content: In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01. The History and Theory of the City as Project
02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03. The Idea of the Polis: Rome, Greece and Beyond
04. The Long Middle Ages and their Counterparts: From the Tuscany of Tuscany to Delhi
05. Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06. Of Absolutism and Enlightenment: Baroque, Defense and Colonization
07. The City of London: As Cross-Cultural Phenomenon
08. Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
09. Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
10. The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

Lecture notes: Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

Literature: There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

Prerequisites / notice: A list of further recommended literature will be found within each chapter of the reader (Skript).

Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

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<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>853-0725-00L</td>
<td>Life and Death</td>
<td>W</td>
<td>3 credits</td>
<td>2V</td>
<td>M. Hagner</td>
</tr>
</tbody>
</table>

Abstract: This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.
Objective
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0426-00L
Paul Feyerabend's Anarchistic Theory of Knowledge
W 3 credits
 Objective
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy and scientific critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

851-0011-00L
The Body in Global History
W 3 credits
 Objective
While being the universal constant which is common to every human being in history, the body is also culturally and historically specific. In this seminar we will examine how ideas of the body have changed throughout history and how these ideas of the body can be useful to understand political, social, and cultural phenomena in particular historical settings.

851-0040-00L
Can It Be Permissible to Kill a Few in Order to Save Many?
W 3 credits
 Objective
First, the relevant literature on moral justifications in trolley cases will be discussed (Foot, Thomson, Kamm, Otsuka, Kagan). Second, neuropsychological research on trolley cases (Greene, Haidt, Berkier, Kamm) and third, applications of such moral reasoning in cases potentially arising in autonomous robots (Rahwan, Nyholm and Smids, Wolkenstein) will be considered.

851-0184-00L
Pluralist Philosophy of Mathematics
W 3 credits
 Objective
The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.

851-0101-77L
Science and the State
W 3 credits
 Objective
This course will reflect on historical and contemporary relations between science and the state. Through various case studies, we will inquire how these two institutions shaped each other. The case studies will cover various scientific disciplines.

851-0101-90L
Aesthetics: On the History and Theory of Beauty
W 3 credits
 Objective
This course will consider the role of science in generating political authority and political reasoning; analyze how political ideas are expressed in science.
The meaning of the "beautiful" seems hard to pin down. Yet intersubjective and objective criteria of the beautiful nevertheless exist. The foundation of aesthetics as a "science" of the beautiful based on sensuous experience temporarily suspended this tension. Since modernity, the question of the beautiful has been ever more open. We shall approach this question theoretically and historically.

The seminar will explore different areas of our social and scientific life where computational practices have a critical impact. The goal is to form a pluralistic conception of computing where its scientific, technical, and cultural aspects occupy a central position. For these reasons, thinking about machines asks today for an interdisciplinary approach, where art is as much a part of the discussion as technology. The rise of an Asian giant faces the global and collective nature of such problems requiring a comprehensive nature of such problems requiring a comprehensive approach. The lectures will be delivered by researchers from ETH and abroad, with different disciplinary backgrounds. As part of the seminar, we shall approach this question from a historical as well as a theoretical perspective.

### Abstract

**Science and Neoliberalism: From the Critique of Planning to Competition and Think Tanks (1930–2000)**

**Objective**

The seminar promotes an understanding of seminal texts in the early philosophy of science (M. Polanyi, J.D. Bernal, etc.) in the context of ideological struggles in the 1930s and 1940s and of the debates about knowledge, science, and society at that time. Moreover, it provides insights into the political and economic foundations of funding policies for education, science, and research that were developed since the 1970s.

**Content**

Neoliberalism is considered one of the most influential economic currents since the last decades of the 20th century. However, neoliberalism not only has a much longer history, going back to the ideological struggles of the 1930s. Since then, it has also been closely linked to debates about the status of knowledge and science in society. Theorists of science, such as Michael Polanyi, were part of neoliberal discussion circles; economists, such as Friedrich Hayek, developed decentralized forms of knowledge as part of market processes. The seminar focuses on the reading and discussion of original and secondary texts on the history of the relationship between knowledge, the book market and the public. Students learn to critically engage with sources as well as research literature from the fields of literary, scientific, and book and media history.

**Literature**


**Abstract**

The lecture offers a survey of the historical trajectories taken by the countries of the Indian subcontinent from the 17th century to the turn of the 21st century. The thematic foci include, but are not limited, to an examination of the question whether or not there was a pre-European South Asian modernity.

**Objective**

Through this course students are acquainted with the history of one of the most important world regions. The objective is not to introduce participants to a richly diverse civilization, they are also encouraged to look at interrelations and make comparisons with the West. Through this approach their knowledge of European history is contextualised in a global framework while simultaneously their intercultural sensitivity is being trained.

**Content**

Knowledge cannot be separated from the forms in which it is expressed. An important genre of (popular) knowledge representation is non-fiction. In this seminar we will look at how non-fiction books are actually made and how they are published and read at different times. Using examples from the history of non-fiction (Yuval N. Harari to Rachel Carson, C.W. Ceram to Charles Darwin/Ernst Haeckel), the seminar will shed light on the changing relationship between knowledge, the market and the public. What topics/subjects are en vogue at particular times? How do non-fiction books produce and narrate knowledge? How do they establish authority, how do they establish evidence? What notions of (scholarly) authorship, what notions of reading are associated with non-fiction books? What political, media, and cultural contexts play a role in this?

**Abstract**

This seminar will explore different areas of our social and scientific life where computational practices have a critical impact. The goal is to provide a pluralistic conception of computing based on what computing looks like when dealing with topics as diverse as climate, law, art, or war. The lectures are delivered by researchers from ETH and abroad, with different disciplinary backgrounds.

**Objective**

By the end of the course, students will be able to describe and compare different conceptions and practices of computing from multiple disciplinary perspectives. They will be able to evaluate both the differences and the convergences between those conceptions, and critically assess their relation to current trends in science, technology, and society.

**Content**

Computing has become omnipresent in all dimensions of scientific and social life. Not only have cultural phenomena increasingly become the object of computational analysis, but computational practices have also proved inseparable from the cultural environment in which they evolve. Therefore, it is urgent to critically address the entanglement of computing practices with the main cultural challenges our epoch is facing. The global and collective nature of many of these problems requires a comprehensive and integrative approach.

**Abstract**

This seminar will explore different areas of our social and scientific life where computational practices have a critical impact. The goal is to provide a pluralistic conception of computing based on what computing looks like when dealing with topics as diverse as climate, law, art, or war. The lectures are delivered by researchers from ETH and abroad, with different disciplinary backgrounds.

**Objective**

By the end of the course, students will be able to describe and compare different conceptions and practices of computing from multiple disciplinary perspectives. They will be able to evaluate both the differences and the convergences between those conceptions, and critically assess their relation to current trends in science, technology, and society.
and Current Debates

Abstract
Technology and society cannot be separated: No society functions without technology. The seminar offers a problem-oriented introduction to basic questions of the history of technology, introduces approaches to the history of technology and discusses selected, ongoing debates.

Objective
The course seeks to provide a critical introduction to the issues, methods, and selected areas of research in the history of technology.

Content
History of technology investigates technological developments that arise in specific historical contexts. These developments are perceived by social groups or entire societies as a means of social change and ultimately find use or are forgotten. The questions that history of technology poses derive from the technological and social change that are a product of contemporary orientation and thinking; current historiographical methods provide the tools for answering these questions.

Prerequisites / notice
Beginn 2. Semesterwoche (27.9.2022)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
<th>Semesters</th>
<th>Instructor</th>
</tr>
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<tbody>
<tr>
<td>851-0516-05L</td>
<td>Mobility and the Border: Migration and Control between Mexico and the USA, 19th–21st Century</td>
<td>3</td>
<td>2S</td>
<td>S. M. Scheuzger</td>
</tr>
<tr>
<td>851-0534-00L</td>
<td>Yemeni Civil War: The Arab Spring, State Formation and Regional Rivalry</td>
<td>3</td>
<td>2V</td>
<td>E. Manea</td>
</tr>
<tr>
<td>851-0345-00L</td>
<td>A Seminar Cycle on Africa</td>
<td>3</td>
<td>2V</td>
<td>A. Mabanckou</td>
</tr>
</tbody>
</table>

Abstract

851-0516-05L
The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

Objective
A) The students know relevant approaches of the studies of migration, they are able to assess the analytical capacities of these approaches and they know how to apply them to concrete events and processes.
B) The students have acquired knowledge of important aspects of the history of migration between Mexico and the United States.
C) The students are able to identify relevant relations between scientific and technological change on the one hand and developments of migration and its control on the other.

Content
The land border between Mexico and the United States, where the 'global North' and the 'global South' meet in the most prominent form worldwide, provides an exemplary case to study how borders generate spaces of agency, constitute human communities and create identities – not only by separating people but also by connecting them. The course is dedicated to the history of migration between Mexico and the United States and to the history of control of these migratory movements. The role of technological change and scientific discourses in these developments will be a subject of special interest in the discussions.

851-0534-00L
This course suggests a framework of analysis for the divergent outcomes of the Arab Uprisings (2011) using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain the disintegration of some countries such as Yemen and Libya and the preservation of states such as Egypt and Tunisia.

Objective
1. To get an introduction into the politics of the Middle East and North Africa, the Arab Spring and its divergent outcomes
2. To look at the different forms of state formations within the MENA region
3. To investigate how the interaction between types of state formation and regional context shaped current situation in the post Arab Spring MENA region
4. To look closer at Yemeni Civil War

Content
Countries that experienced popular uprisings in the 2011 Arab Spring had a range of outcomes. Some countries, like Tunisia and Egypt, had a long tradition of centralised state apparatus and a strong national identity. Their outcomes were, respectively, a fragile democratisation process and a reversion to military authoritarianism. Other countries, such as Yemen, Syria and Libya, are newer states that lack a solid national identity, and society is divided along tribal, religious sectarian, linguistic, and/or regional lines. There the outcome has been a meltdown of the political order, along with civil war and fragmentation. Why?

This course suggests a framework of analysis for the divergent outcomes using Yemeni Civil War as an example. It argues that the interaction between different types of state formation and regional context can explain, respectively, the disintegration of countries such as Yemen, Syria and Libya; as well as the preservation of the Bahraini system, despite its ethnic nature. Egypt and Tunisia provide further variants in their well-developed statehood and sense of national identity. Yemen will be used as a case study for examining this complexity among the countries that experienced the Arab spring.

851-0345-00L
Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

Objective
This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe.
In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called "littérature ‘nègre’", which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the "négritude", this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d’Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the "immigration novel".

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbougar Sarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of "ghettoization". African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of "Noirs en France"
On January 18, 2022, the documentary "Noirs en France" (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the "question of being black" still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary " Noirs en France ".

NB.
The names of the guests in the seminars might change.

851-0199-00L History of Mathematics from Antiquity to 17th Century W Magnitudes, Numbers and Equations 3 credits 2V E. Sammarchi
Abstract
Far from being fixed and timeless notions, magnitudes, numbers and equations are three objects that were conceived by mathematicians in a -sometimes radically- different way, and that were influenced by their historical context. The course analyses the evolution of these objects from Greek Antiquity to the beginning of 17th century, via Arabic and Latin Middle Age, and the Italian Renaissance.

Objective
The course aims are:
- to introduce students to the historical dimension of mathematics;
- to develop a critical understanding of mathematical notions;
- to have a general idea of the history of mathematics until 17th century;
- to acquire skills in order to read and comment mathematical texts written in the past ages and in different cultures.

Content
After a methodological introduction to the history of mathematics, we analyse texts written by mathematicians such as Euclid, al-Khwarizmi, al-Khayyam, Fibonacci, Cardano, Stifel, Descartes. The aim is to understand what magnitudes, numbers and equations are for these scholars. Students are also led to consider:
- the cultural and sociological consequences of the invention of the printed book;
- the history of the classification of mathematical sciences;
- the history of the scientific institutions.

Literature

851-0084-00L Sound Studies and Literature – A New Paradigm?

The lecture presents the methodological diversity of sound studies insofar as they are related to the study of literature and undertakes to critically assess exemplary works. It offers an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.
Introduction

Is literature silent? The paper pages of the book or the screen of the tablet that we look at while reading might suggest so. Nevertheless, when reading, one cannot help but have the impression that literature contains sound. Doesn’t it allow us to identify authors by their “voice,” for example, or guide our reading through repetitions and assonances? Does it not seem to reproduce the sonic world?

In other words: How is the relationship between literature and sound to be thought of? In recent years a concept of ‘sound’ has emerged in the realm of the so-called sound studies which thinks of acoustic phenomena in their connection with human perceptions and actions (Morat/Ziemer 2018). Research in the context of the ‘sonic turn’ assumes that literature both generates and stores sound and that our understanding of literature should be closely linked to the conceptualization and writing practice of sound as well as the conditions of its production and reception.

Strongly interdisciplinary, this research thus combines perspectives from the cognitive sciences, with approaches from the technical sciences and cultural studies. At times, it has argued to dispense with the traditional fixation on writing and instead to approach literature also through sound practices and listening techniques. These practices and techniques should not only be object of studies, but, employing “listening as a research method” (Holger Schulze), should be integrated into the research methodology.

The lecture will confront the methodological diversity of sound studies insofar as they are related to the study of literature and will undertake to critically assess them. It will offer an overview of central aspects of the sonic turn, with the aim of presenting and examining methodological instruments for literary studies oriented towards the history of knowledge.

851-0328-00L No Borders: Galileo, Calvino, Primo Levi W 3 credits 2V M. Bucciantini

Abstract
Without borders means without disciplinary boundaries, without manuals and school programs that force certain authors to stay “inside” schemes and simplifications. It means freeing oneself from the obligations that certain university systems impose on their students, with the risk of limiting one’s view of the great authors as Galileo, Italo Calvino and Primo Levi.

Objective
Through the reading and commentary of texts and images, we will narrate the relationship between science and literature, starting from the contexts in which these three authors found themselves living and discussing the problems and issues that each of them had to deal with.

Content
Without borders means without disciplinary boundaries, without manuals and school programs that force certain authors to stay “inside” schemes and simplifications. It means freeing oneself from the obligations that certain university systems impose on their students, with the risk of limiting one’s view of the great authors.

This is the case with Galileo, Italo Calvino and Primo Levi. Each of them has been many things at once. The first was a scientist but also a philosopher and expert technologist, a builder of mechanical devices and scientific instruments; the second was a novelist but also an editorial consultant and a refined essayist and literary critic; the third was a chemist, writer and witness to an event that marked the history of the twentieth century.

The course will explore, on the one hand, the central nodes of Galilean science and, on the other, its reception in two “hybrid” authors such as Calvino and Levi. Through the reading and commentary of texts and images, we will narrate the relationship between science and literature, starting from the contexts in which these three authors found themselves living and discussing the problems and issues that each of them had to deal with.

851-0311-00L Literature and Knowledge / Science and Fiction W 3 credits 2V A. Kilcher

Abstract
Not only the specific genre of "Science Fiction", but fictitious (literary) texts in general are fundamentally about the forms and functions of knowledge and science. In the lecture, these are developed theoretically and discussed using examples.

Objective
1) Introduction to literary theory
2) Theories of science and fiction
3) Introduction to literary scientific knowledge research

Content
Not only the specific genre of "Science Fiction", but fictitious (literary) texts in general are fundamentally about the forms and functions of knowledge and science. In the lecture, this fundamental question of knowledge of literature is developed theoretically and systematically and discussed using examples from science and literature. Contrary to what has long been claimed, more recent theoretical approaches assume that literature is not in conflict with scientific knowledge. Rather, it is part of the social formation, order and negotiation of knowledge. This applies not only to "science fiction" but in general to the "science" of "fiction", i.e. to the knowledge of literature. In the fictional form of literature, models of knowledge are generated, also with a critical or utopian intention (as in "science fiction"). Moreover, literature draws attention to the central role of order and representation in the sciences, i.e. to their aesthetic and narrative forms.

851-0436-00L Popularizing Science. Nonfiction Books Between Academy and Public W 3 credits 2S I. Barnar

Abstract
Science needs to be popularized in order to have an impact on society. Conversely, what is thought, read, and communicated outside the universities has an effect on research. The seminar deals with the history of popular knowledge focusing on the non-fiction book.

Objective
The seminar focuses on the reading and discussion of original and secondary texts on the history of the relationship between knowledge, the book market and the public. Students learn to critically engage with sources as well as research literature from the fields of literary, scientific, and book and media history.

Content
Knowledge cannot be separated from the forms in which it is expressed. An important genre of (popular) knowledge representation is non-fiction. In this seminar we will look at how non-fiction books are actually made and how they are published and read at different times. Using examples from the history of non-fiction (Yuval N. Harari to Rachel Carson, C.W. Coram to Charles Darwin/Ernst Haeckel), the seminar will shed light on the changing relationship between knowledge, the market, and the book format. What topics/subjects are en vogue at particular times? How do non-fiction books produce and narrate knowledge? How do they establish authority, how do they establish evidence? What notions of (scholarly) authorship, what notions of reading are associated with non-fiction books? What political, media, and cultural contexts play a role in this?

851-0360-00L The Noise of Culture: Literature, Babel, and the Meaning of Meaning W 3 credits 2V P. Gerard

Abstract
When is noise—din in the pub, static on the line, attenuation of the signal—a problem for communication? When is noise art? We’ll ask James Joyce.
The overall aim of this class is to reflect, in theory and through literature, upon the fundamental category of time, the critical insight being
to re-examine several central premises of traditional literary criticism, including meaning, intention, and representation.

In this course we will explore how noise functions both as a threat to meaning and as a source of new order, with special attention to
literary texts. We will begin with the myth of Babel and look at several subsequent attempts to redress the noisy confusion. As we will learn,
noise is a necessarily "parasitical" term; we will follow its modern uses across a range of 20th century texts drawn from the fields of
semiotics (Ogden, Eco), cybernetics (Wiener, Bateson), and philosophy (Serres, Derrida). Literary texts by James Joyce, Ezra Pound, and
John Cage.

The Modern Literary and Artistic Avantgarde in Its
European Dimension

The modernist Avant-Garde movements are characterized by a radical rhetoric of apocalypse and rebirth, the genesis of another world and
a new mankind. The extension of the "intrinsic logic of the aesthetic form into the social fabric" (H. Ehrlicher), and likewise the intensive
examination of the latest technical advancements, new forms of media and their combination, unites them.

Avant-garde movements are characterized by progressive notions on art, social and political issues as well as by radical criticism on the
current circumstances. This is why the specific characteristics of the historic avant-garde of the early 20th century will be a central theme of
this lecture: they cannot be separated from the experience of modernity, of the catastrophic course of the First World War, and of the
concept of new models of society whose political implementation is a major goal after the end of the war.

The lecture is part of the "Science in Perspective" course programme aimed at enabling the students to deal with avant-garde texts and
artworks independently, especially in the context of literary and cultural history. They will also explore theoretical positions such as Peter
Bürger's assumption that in the course of the historic avant-garde movements "the social subsystem that is art enters the stage of self-
criticism".

The contemplation of the historic avant-garde is a crucial prerequisite to find scientific answers to the question about the possible effects of
art nowadays. Thus, in this lecture the topic is on the one hand tackled from the historic perspective: literary texts and manifests by Heym,
von Hoddis, Werfel, Lasker-Schüler, Toller, Marinetti, Ball, Tzara, Huelsenbeck, Hausmann, Apollinaire, Breton, Gold, and others will be
read. On the other hand, debates of cultural policy and literary theory which were initiated by the avant-garde will be discussed (texts by
Lukács, Benjamin, Bloch, Brecht, Adorno).

This lecture examines the modernist Avant-Garde movements by addressing three specific aspects. First, the ambivalent reception of
technological innovations, second, the aesthetic programmes which focused on specific developments at the close of the 19th century, and
third, political activism and the establishment of a new social model through Avant-Garde movements prior to World War One, and,
following the disastrous consequences of World War One, an activism which was accused of being politically ineffective and lacking
resilience to totalitarian ideologies.

Narrating Time

It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is
indeed indispensable means of explanation. Literature makes all this tangible by bringing the uneven clockings, overlaps, and loops of
experiential time to light, which still holds true when the literary representation of time fails, i.e., when it becomes clear that the transfer of
purpose of more convenient division, measurement and precalculation of time processes. The world, however, also holds more complex
experiences of time, which cannot be calculated mathematically or explained by the law of causation alone. Certain experiences of time
simply necessitate narration (which is why even in the philosophy of science scholars have come to regard narrative as a legitimate and
indeed indispensable means of explanation). Literature makes all this tangible by bringing the uneven clockings, overlaps, and loops of
experiential time to light, which still holds true when the literary representation of time fails, i.e., when it becomes clear that the transfer of
experienced time into narrated time also entails certain deformations and even losses.

A Seminar Cycle on Africa

Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main
subjects, including the western perception of this literary creation.

This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in
France - and beyond - in Europe.
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9:30 a.m. - 12:30 p.m.
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2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d'Afrique noire

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9:30 a.m.-12:30 p.m.
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2:00 - 4:30 pm
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Guest Mohamed Mbougar Sarr, Senegalese writer, Prix Goncourt

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Lesson 3: On the Western perception of African literature
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2:00 - 4:30 pm
Seminar 3: Guest Charlyne Efia, Gabonese novelist

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9:30am-12:30pm
Lesson 4: From Africa to France: Screening of "Noirs en France"
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2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary "Noirs en France".

NB.
The names of the guests in the seminars might change.

Economics

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>851-0626-01L</td>
<td>International Aid and Development</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>I. Günther</td>
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<td></td>
<td>Does not take place this semester.</td>
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<tr>
<td></td>
<td>Prerequisites: Basic knowledge of economics</td>
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<tr>
<td>Abstract</td>
<td>The course gives economic and empirical foundations for a sound understanding of the instruments, prospects and limitations of international development aid.</td>
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<tr>
<td>Objective</td>
<td>Students have a theoretically and empirically sound understanding of the prospects and limitations of international development aid. Students are able to critically discuss the various aid instruments of bi- and multilateral donors and NGOs.</td>
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<tr>
<td>Content</td>
<td>Introduction to the Determinants of Underdevelopment; History of Aid; Aid and Development; Theories and Empirics; Political Economy of Aid; Experience and Impact of Aid; New Instruments of Aid; e.g. Micro-Finance, Budget-Support; Fair-Trade.</td>
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<tr>
<td>Literature</td>
<td>Articles and book abstracts will be uploaded to a course website.</td>
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<td>851-0609-06L</td>
<td>Governing the Energy Transition</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>T. Schmidt</td>
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<td></td>
<td>Does not take place this semester. Primarily suited for Master and PhD level.</td>
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<tr>
<td>Abstract</td>
<td>This course addresses the role of policy and its underlying politics in the transformation of the energy sector. It covers historical, socio-economic, and political perspectives and applies various theoretical concepts to understand specific aspects of the governance of the energy transition.</td>
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<tr>
<td>Objective</td>
<td>- To gain an overview of the history of the transition of large technical systems</td>
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<td></td>
<td>- To recognize current challenges in the energy system to understand the theoretical frameworks and concepts for studying transitions</td>
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<tr>
<td></td>
<td>- To gain knowledge on the role of policy and politics in energy transitions</td>
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<tr>
<td>Content</td>
<td>Climate change, access to energy and other societal challenges are directly linked to the way we use and create energy. Both the 2015 United Nations Paris climate change agreement and the UN Sustainable Development Goals make a fast and extensive transition of the energy system necessary. This lecture introduces the social and environmental challenges involved in the energy sector and discusses the implications of these challenges for the rate and direction of technical change in the energy sector. It compares the current situation with historical socio-technical transitions and derives the consequences for policy-making. It introduces theoretical frameworks and concepts for studying innovation and transitions. It then focuses on the role of policy and policy change in governing the energy transition, considering the role of political actors, institutions and policy feedback. The grade will be determined by a final exam.</td>
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<tr>
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<td>151-0757-00L</td>
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<td>W</td>
<td>R. Züst</td>
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<td>363-0387-00L</td>
<td>Corporate Sustainability</td>
<td>3</td>
<td>W</td>
<td>V. Hoffmann, J. Meuer, A. Nunez-Jimenez</td>
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<tr>
<td>363-0503-00L</td>
<td>Principles of Microeconomics</td>
<td>3</td>
<td>W</td>
<td>M. Filippini</td>
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**Environmental Management**

**Abstract**
An environmental management system has the objective to continuously improve the environmental performance of the activities, products and services of a company. The company has to introduce different management procedures. The goal of this lecture is to provide basics and specific procedure to implement the environmental dimension in the planning and decision making processes of an organisation.

**Objective**
Overview on environmental management and environmental management systems, general methods and principles.

**Content**
Introduction to environmental management / environmental management systems, energy and material flows; economical and ecological problems in industry; characterisation of an enterprise (incl. management handbook); structure and contents of an environmental management system; overview on the ISO 14001 ff. series; methods for environmental evaluation and assessment; integrated management systems; planning methodology and life-cycle-design design; planning exampl

**Lecture notes**
Information about environmental management and environmental management systems will be provided by a CD or mail.

**Literature**
a list with literatures and links will be provided

**Prerequisites / notice**
Delivery of a case study, worked out in groups. Language: Teaching in English on request.

**Corporate Sustainability**

**Abstract**
The lecture explores current challenges of corporate sustainability and prepares students to become champions for sustainable business practices. In the beginning, traditional lectures are complemented by e-modules that allow students to train critical thinking skills. In the 2nd half of the semester, students work in teams on sustainability challenges related to water, energy, mobility, and food.

**Objective**
- Students assess the limits and the potential of corporate sustainability for sustainable development
- develop critical thinking skills (argumentation, communication, evaluative judgment) that are useful in the context of corporate sustainability using an innovative writing and peer review method
- recognize and realize opportunities through team work for corporate sustainability in a business environment
- present strategic recommendations in teams with different output formats (tv-style debate, consultancy pitch, technology model walk-through, campaign video)

**Content**
In the first part of the semester, Prof. Volker Hoffmann and Dr. Johannes Meuer will share their insights on corporate sustainability with you through a series of lectures. They introduce you to a series of critical thinking exercises and build a foundation for your group work. In the second part of the semester, you participate in one of four tracks in which SusTec researchers will coach your groups through a seven-step program. Our ambition is that you improve your analytic and organizational skills and that you can confidently stand up for corporate sustainability in a professional setting. You will share the final product of your work with fellow students in a final puzzle session at the end of the semester.

**Lecture notes**
Presentation slides will be made available on moodle prior to lectures.

**Literature**
Literature recommendations will be distributed during the lecture

**Prerequisites / notice**
TEACHING FORMAT/ ATTENDANCE: Please note that we aim to offer you the course in-class and online, but at this point we cannot guarantee that a purely online participation is possible. Irrespective of the format (in-class or online), the course includes several mandatory sessions that participants must attend to successfully earn credit points.

**Principles of Microeconomics**

**Abstract**
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

**Objective**
The learning objectives of the course are:

(1) Students must be able to discuss basic principles, problems and approaches in microeconomics.
(2) Students can analyse and explain simple economic principles in a market using supply and demand graphs.
(3) Students can contrast different market structures and describe firm and consumer behaviour.
(4) Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
(5) Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
(6) Students can apply simple mathematical concepts on economic problems.

**Content**
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture “Principles of Microeconomics” is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

**Topics covered by the course are:**
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

**Lecture notes**
Lecture notes, exercises and reference material can be downloaded from Moodle.
Literature

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book: N. Gregory Mankiw and Mark P. Taylor (2020), "Microeconomics", 5th edition, South-Western Cengage Learning.

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.

Fostered competencies

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Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature

This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

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363-0566-00L  Principles of Macroeconomics  W 3 credits  2V  J.-E. Sturm

Abstract
This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

Objective
This course helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society’s resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

Lecture notes
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

Literature

This book can also be used for the course ‘363-0503-00L Principles of Microeconomics’ (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.

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363-0561-00L  Financial Market Risks  W 3 credits  2G  not available

Does not take place this semester.
Abstract
I aim to introduce students to the concepts and tools of modern finance and to make them understand the limits of these tools, and the many problems met by the theory in practice. I will put this course in the context of the on-going financial crises in the US, Europe, Japan and China, which provide fantastic opportunities to make the students question the status quo and develop novel solutions.

Objective
The course explains the key concepts and mechanisms of financial economics, their depth and then stresses how and why the theories and models fail and how this is impacting investment strategies and even a global view of citizenship, given the present developing crises in the US since 2007 and in Europe since 2010.

- Development of the concepts and tools to understand these risks and master them.
- Working knowledge of the main concepts and tools in finance (Portfolio theory, asset pricing, options, real options, bonds, interest rates, inflation, exchange rates)
- Strong emphasis on challenging assumptions and developing a systemic understanding of financial markets and their many dimensional risks

Content
1- The Financial Crises: what is really happening? Historical perspective and what can be expected in the next decade(s). Bubbles and crashes. The illusion of the perpetual money machine.

2- Risks in financial markets
- What is risk?
- Measuring risks of financial assets
- Introduction to three different concepts of probability
- History of financial markets, diversification, market risks

3- Introduction to financial risks and its management.
- Relationship between risk and return
- Portfolio theory: the concept of diversification and optimal allocation
- How to price assets: the Capital Asset Pricing Model
- How to price assets: the Arbitrage Pricing Theory, the factor models and beyond

4- Financial markets: role and efficiency
- What is an efficient market?
- Financial markets as valuation engines: exogeneity versus endogeneity (reflexivity)
- Deviations from efficiency, puzzles and anomalies in the financial markets
- Financial bubbles, crashes, systemic instabilities

5- An introduction to Options and derivatives
- Calls, Puts and Shares and other derivatives
- Financial alchemy with options (options are building blocks of any possible cash flow)
- Determination of option value; concept of risk hedging

6- Valuation and using options
- A first simple option valuation model
- The Binomial method for valuing options
- The Black-scholes model and formula
- Practical examples and implementation
- Realized prices deviate from these theories: volatility smile and real option trading
- How to imperfectly hedge with real markets?

7- Real options
- The value of follow-on investment opportunities
- The timing option
- The abandonment option
- Flexible production
- Conceptual aspects and extensions

8- Government bonds and their valuation
- Relationship between bonds and interest rates
- Real and nominal rates of interest
- Term structure and Yields to maturity
- Explaining the term structure
- Different models of the term structure

9- Managing international risks
- The foreign exchange market
- Relations between exchanges rates and interest rates, inflation, and other economic variables
- Hedging currency risks
- Currency speculation
- Exchange risk and international investment decisions

Lecture notes
Lecture slides will be available on the site of the lecture

Literature
Corporate finance
Brealey / Myers / Allen
Eight edition

Prerequisites / notice
Not for students belonging to D-MTEC!

351-0555-00L Open- and User Innovation W 3 credits 2G S. Häfliger, S. Spaeth

Abstract
The course introduces the students to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through the course they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies.
Objective

The course includes both lectures and exercises alternately. The goal is to understand the opportunity of user innovation for management and develop strategies to harness the value of user-developed ideas and contributions for firms and other organizations.

The students actively participate in discussions during the lectures and contribute presentations of case studies during the exercises. The combination should allow to compare theory with practical cases from various industries.

The course presents and builds upon recent research and challenges the students to devise innovation strategies that take into account the availability of user expertise, free and public knowledge, and the interaction with communities that span beyond one organization.

Performance assessment will be: a written group essay based on the open/user innovation case that participants will research and present during the block seminar (including the slides). Each group will have to hand in a 15-20 page essay, details on the required format and the content will be distributed during the course. Active class participation is required.

Content

This course on user innovation extends courses on knowledge management and innovation as well as marketing. The students are introduced to the long-standing tradition of actively involving users of technology and other knowledge-intensive products in the development and production process, and through own cases they develop an entrepreneurial understanding of product development under distributed, user-centered, or open innovation strategies. Theoretical underpinnings taught in the course include models of innovation, the structuration of technology, and an introduction to entrepreneurship.

Lecture notes

The slides of the lectures are made available and updated continuously through the SMI website:

Literature

Relevant literature for the course includes slides and reading assignments. Papers will be made available through a corresponding Moodle group.

701-0747-00L

Environmental Policy of Switzerland

W 3 credits 2G E. Lieberherr

Abstract

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples.

Objective

Beyond acquiring basic knowledge about public policy analysis, this course teaches students how to analytically address current and concrete questions of environmental policy. Through exercises the students learn about political science concepts and frameworks as well as real-life political decision-making processes. The well-grounded examination of complex political conflict situations is an important precondition for the entry into the (environmental policy) workforce or a future research career.

Content

The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

Lecture notes

Reader and additional lecture material will be posted on Moodle.

Literature

The reader and additional lecture material on moodle.

Prerequisites / notice

The detailed semester program (syllabus) is made available to the students at the beginning of the semester. During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.

Fostered competencies

Subject-specific Competencies

Concepts and Theories assessed

Method-specific Competencies

Analytical Competencies assessed

Social Competencies

Sensitivity to Diversity assessed

Personal Competencies

Critical Thinking assessed

Self-direction and Self-management assessed

351-1158-00L

Economics

Not for students belonging to D-MTEC!

W 3 credits 2G U. Renoid, T. Bolli, P. McDonald, M. E. Oswald-Egg, F. Pusterla, A. Zubovic

Abstract

This course introduces basic economic concepts and theories. Beginning with microeconomics, the course starts with the topics of supply and demand, markets, and behavioral economics before moving on to the key macroeconomic concepts of national accounts, the labor market, trade, and monetary policy.

Objective

After successful completion of the course you will be able to:

- Describe the basic micro- and macroeconomic problems and theories.
- Introduce economic reasoning appropriately to a given topic.
- Evaluate economic measures.

Content

Households, firms, supply and demand: How are household preferences and consumption patterns formed? How does a household react to price changes? How are goods prices formed? At what prices are companies willing to offer goods? How do we make economic decisions?

Markets: What is "perfect competition" and how does a competitive market work? Are monopolies always a bad thing? How can the state influence the market?

Market failure: What happens when prices give wrong signals?

Labour market: How do supply and demand work in the labour market? What influences unemployment?

National accounts: How big is the Swiss economy?

Foreign trade: Why do countries trade with each other? What are the consequences for the domestic market?

Money and inflation: What exactly is money? How does money creation work and what happens when there is too much (or too little) money on the market?

Students will be asked to apply these concepts to issues in their own field of study and to current issues in society. This goal will be achieved through participation in exercises, class discussions and reading material from current media. By the end of the course, students should be able to apply economic analysis confidently and independently.

Lecture notes

no script available

Literature


Prerequisites / notice

Sie brauchen keine Vorkenntnisse, um dem Kurs zu folgen.
Introduction to Microeconomics

**GESS (Science in Perspective):**
This course is only for students enrolled in a Bachelor's degree programme.

Students enrolled in a Master's degree programme may attend "Principles of Microeconomics" (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed "Principles of Microeconomics" (LE 363-0503-00L), then you will not be permitted to attend it again.

**Abstract**
The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

**Objective**
Students acquire a deeper understanding of basic microeconomic models. They acquire the ability to apply these models in the interpretation of real world economic contexts. Students acquire a reflective and contextual knowledge on how societies use scarce resources to produce goods and services and distribute them among themselves.

**Content**
Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

**Lecture notes**
Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

**Literature**

**Prerequisites / notice**
This course "Einführung in die Mikroökonomie" (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics" for Master students.

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**Philosophy**

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<td>Research Ethics</td>
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Number of participants limited to 40

**Abstract**
Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

**Objective**
Participants of the course Research Ethics will
- Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
- Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people's arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
I. Introduction to Moral Reasoning
1. Ethics - the basics
1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in "Research Ethics"

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a "right" answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRP/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and research validity
1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes
Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice
What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!)
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…)

Fostered competencies
Subject-specific Competencies Conceptual Understanding and Theories
- Analytical Competencies
- Decision-making
- Problem-solving
Method-specific Competencies
- Communication
- Cooperation and Teamwork
Social Competencies
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
Personal Competencies
- Self-awareness and Self-reflection

701-0703-00L Environmental Ethics W 2 credits ZV A. Deplazes Zemp
Abstract
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Content
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Lecture notes
Presentation slides of the individual sessions will be distributed, including the most important theories and keywords; extended reading lists.
War between Humans, or War against Nature?

3 credits

The U.S. philosopher Chauncey Wright wrote in 1865 in his critique of the famous 19th century popular philosopher Herbert Spencer:

"Progress is a grand idea, – Universal Progress is a still grander idea. It strikes the key note of modern civilization. Moral idealism is the religion of our times. What the ideas of God, the One, and the All, the Infinite First cause, were to an earlier civilization, such are Progress and Universal Progress to the modern world, – a reflex of its moral ideas and feelings." (Chauncey Wright, The Evolutionary Philosophy… Vol. 1. 2000, S. 69). The lecture will give an introduction into the different concepts of progress and try to evaluate them against the background of the current epistemological situation.

Literature
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O'Neill et al., Environmental Values, 2008
- Konrad Ott/Jan Diers/Klieske Vogt-Kleschin, Handbuch Umweltethik, 2016

Prerequisites / notice
The procedure for accumulating CP will be explained at the start of the term.
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

851-0101-87L World Views in the Digital Age

Does not take place this semester.

W 3 credits 2S  J. Leuthold

Abstract
World views guide our thoughts and our actions even though we may not be aware of it. By means of lectures, discussions and contributions of participants, we examine elements of world views regarding the underlying philosophical concepts and their relations to the sciences, philosophy and religion.

Objective
Students shall obtain a basis for their own exploration of world views, with a focus on new technological developments. Prior knowledge of philosophical concepts and history is not required but are studied in the course.

851-0197-00L Medieval and Early Modern Science and Philosophy

Does not take place this semester.

W 3 credits 2V  to be announced

Objective
Students shall obtain a basis for their own exploration of world views, with a focus on new technological developments. Prior knowledge of philosophical concepts and history is not required but are studied in the course.

Abstract
The course analyses the evolution of the relation between science and philosophy during the Middle Age and the Early Modern Period.

Content
The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.

851-0042-00L Democracy (Theory) and Challenges Posed by the Digital Transformation

Does not take place this semester.

W 3 credits 2S  N. Mazouz

Abstract
First, an overview of different theories of democracy will be given in order to make explicit their normatively distinguished features. Second, using examples of the social application of digital technologies, controversies about their impact and normative evaluation are discussed.

Objective
Students gain an overview of different theories of democracy and the associated different types of challenges to democracy posed by the digital transformation of society. They will be enabled to interpret complex texts, to identify the argumentation, to reflect critically and to put it up for discussion.

Content
Researchers agree that the digital transformation of society is a challenge to democracy. What is disputed is how exactly it challenges or even endangers it. One reason for the disagreement is certainly due to different descriptions and assessments of the precise social effects and risks of various digital technologies. A second reason has to do with the diversity of theories of democracy. In democratic theory, a distinction is usually made between liberal, republican, pluralist-participatory, and deliberative models of democracy (and often many more). Depending on which model is used (and how exactly it is determined), political participation, elections, accountability of politicians, the role of central legal-political institutions (such as the constitution), political culture, and the quality of discourse in the political public sphere are conceived and evaluated differently.

In a first step, this seminar will provide an overview of different theories of democracy, with the aim of making explicit the normative features of important elements of democracy (such as political participation). In a second step, examples of the social application of digital technologies are used to discuss both divergent descriptions of their impact and controversies about normative evaluations in the research literature. In a third step, these essays are related to the models of democracy elaborated in the first part and analyzed.

851-0176-00L Progress

W 3 credits 2V  M. Hampe

Abstract
Science and technology are projects that are usually described as “progressing”. Earlier findings and inventions are used to create new ones. Later researchers stand on the “shoulders of giants” of those who worked before them. But is this a development toward truth and for the better?

Objective
Acquire knowledge of basic concepts of progress and their evaluation options.

Content
The U.S. philosopher Chauncey Wright wrote in 1865 in his critique of the famous 19th century popular philosopher Herbert Spencer: "Progress is a grand idea, – Universal Progress is a still grander idea. It strikes the key note of modern civilization. Moral idealism is the religion of our times. What the ideas of God, the One, and the All, the Infinite First cause, were to an earlier civilization, such are Progress and Universal Progress to the modern world, – a reflex of its moral ideas and feelings." (Chauncey Wright, The Evolutionary Philosophy..... Vol. 1. 2000, S. 69). The lecture will give an introduction into the different concepts of progress and try to evaluate them against the background of the current epistemological situation.

851-0184-00L Pluralist Philosophy of Mathematics

W 3 credits 2V  R. Wagner

Abstract
This course will follow Michèle Friend's book "pluralism in mathematics”. It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration.
The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralistic and paraconsistent philosophical approaches.

annotated.

Participants should learn to know some philosophical accounts of intelligence, reason, and agency. This knowledge should enable them to evaluate the pro and con of answers to questions of the following kind:

1. Is human deliberation and argumentation essentially algorithmic?
2. Is AI confined to smart solutions of given problems or is AI also able to revise the framing of problems?
3. Could artificial agents like robots be responsible for their behavior?
4. Do my smartphone and I constitute an extended, hybrid mind?
5. How should we deal with AI-based machines in our social and political life?

It seems quite natural to capture past times by way of narrative representation. Certain theorists and historians even claimed that time is inherently narrative and therefore articulated best in the form of narrations. But is it even possible to narrate time? What kind of translation is that? And, above all, what are the costs of, and the resistances to, such a translation?

The overall aim of this class is to reflect, in theory and through literature, upon the fundamental category of time, the critical insight being that a discretely progressing and uniformly clocked time is only one way of looking at temporal processes. In fact, this standard clock, with which the mathematical sciences calculate and which is mainly used in the technical field, is only a special case, an abstraction for the purpose of more convenient division, measurement and precalculation of time processes. The world, however, also holds more complex experiences of time, which cannot be calculated mathematically or explained by the law of causation alone. Certain experiences of time simply necessitate narration (which is why even in the philosophy of science scholars have come to regard narrative as a legitimate and indeed indispensable means of explanation). Literature makes all this tangible by bringing the uneven clockings, overlaps, and loops of experiential time to light, which still holds true when the literary representation of time exists, i.e., when it becomes clear that the transfer of experienced time into narrated time also entails certain deformations and even losses.

According to Bernard Waldenfels (UZH)

No enrolment to this course at ETH Zurich. Book the corresponding module directly at UZH as an incoming student. 

UZH Module Code: 23LB002

Mind the enrolment deadlines at UZH: 
https://www.uzh.ch/cmsssl/en/studies/application/deadline s.html

One can differentiate the same and the other looking at them from a third standpoint, 'from outside' – a methodological approach typical for ecological crises and growing social inequalities rise the urgent question: Is the global way we are doing economics reasonable? – Which kind of wealth is illegitimate? Is a policy of de-growth needed for protecting our ecological niche? Will technological devices e.g. AI-driven market designs for public goods be the solution of a change of attitudes necessary to cope with such problems?

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4. Do my smartphone and I constitute an extended, hybrid mind?
5. How should we deal with AI-based machines in our social and political life?
Abstract

The course offers an introduction to analytical, phenomenological and hermeneutic philosophy of religion. Influential positions, vital questions and significant developments will be discussed and critically reflected.

Objective

Special emphasis will be placed on the relationship between religious and scientific discourse in the 20th century. To get a better grasp of the complexity of this relationship, different narratives will be examined as to how the modern ideal of modelling all cognitive values on scientific ones came to exert supreme authority in Western societies. The still prevalent, mainstream view has deep roots in 19th century positivism, which assumed a necessary historical progress from religion to metaphysics to science. In this perspective, scientific knowledge uncovers “objective” reality by displacing superstition and more ‘primitive’, mythical or metaphysical accounts of human and cosmic origins. On the other hand, there is the more recent, “heterodox” view advanced by philosophers and historians of science like S. Gaukroger, that the success of science in the West in the early-modern era might be related to its close association with theology rather than attempts to emancipate itself from it. The question here arises: What traditional ideas of God and religious faith contributed to the modern ideal of knowledge and truth -- an ideal which, in a strange twist of historical irony, finally led to the seeming exclusion of all religious discourse from the properly scientific quest for real knowledge and truth in present-day secular societies?

376-1661-00L Ethics of Life Sciences and Biotechnology

Abstract

This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences

Objective

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

A. Identify ethical issues in life sciences and biotechnology.
B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
C. Become aware of relevant legal and public policy frameworks.
D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
E. Recognize how ethical issues relate to different accounts of technology and innovation.
F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
G. Autonomously anticipate ethical issues.
H. Propose and communicate solutions to ethical challenges and dilemmas.

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Usable analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

851-0345-00L A Seminar Cycle on Africa

Abstract

Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

Objective

This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe.
In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called “littérature ‘nègre’”, which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the “négritude”, this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d'Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the ‘immigration novel’.

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbougarsarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of “ghettoization”. African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of “Noirs en France”
On January 18, 2022, the documentary “Noirs en France” (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the “question of being black” still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary “Noirs en France”.

NB.
The names of the guests in the seminars might change.

★★ Political Science

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
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<tr>
<td>851-0589-00L</td>
<td>Technology and Innovation for Development</td>
<td>W Dr</td>
<td>3 credits</td>
<td>2V</td>
<td>P. Aerni</td>
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</table>

Abstract
Technology and Innovation contribute to sustainable development if institutional framework conditions create the right incentives. The course discusses the challenges associated with technological change from an interdisciplinary and practice-oriented perspective taking into account legal, economic, anthropological and development aspects.

Objective
- to recognize the challenges and opportunities of technology and innovation to enable inclusive and sustainable change
- to become familiar with policy instruments designed to support innovative entrepreneurs that convert new knowledge into new products and services with positive externalities for society and the environment
- to understand the politics of regulation and its impact on technological change
- to learn how to think in terms of economic ecosystems that enable a more sustainable use of scarce resources rather than individuals that merely compete in the consumption of such resources

Content
Science and Technology Policy is normally associated with the improvement of national competitiveness; yet, it is also an integral part of effective environmental and development policies. The course will discuss the challenges and opportunities of technological change in terms of sustainable development and show how public policy on the national and the international level is responding to this change.

In this context, students are to become familiar with the basic principles of political economy and New Growth Theory and how such theories help explain political decisions as well as political outcomes in the area of Science, Technology and Innovation. State interventions are either designed to regulate (e.g. environmental regulations, anti-trust law) or facilitate (e.g. intellectual property rights protection, public investment in R&D and technical education, technology transfer) technological change. This will be illustrated by looking at different industries and different national systems of innovation. Subsequently the positive and negative consequences for society and the natural environment will be discussed from a short-term and a long-term perspective.

Lecture notes
Reader with issue-specific articles. E-version is partly available on Moodle
This course analyzes the foundations and challenges of Swiss foreign policy. After reviewing the history of foreign policy conceptions since the early 20th century, we will discuss the determining factors of Swiss foreign policy and examine, together with guest speakers from the foreign ministry, current international developments and respective foreign policy challenges.


Romer, P. 2020. What It Takes To Be a Leader in Both Basic Science and Technological Progress. Statement for House Budget Committee Hearing on Federal R&D (https://paulromer.net/statement-for-house-budget-committee/)


The class will be taught in English.

The 2-hour course (12-14h) will be held as a series of lectures with guest lectures. The course materials will be available in form of an electronic Reader at the beginning of the semester.

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Students will be asked to make a contribution in class choosing one out of three options:
(a) presentation in class (15 Minutes) based on a paper to be discussed on a particular day in class.
(b) review paper based on a selected publication in the course material
(c) preparation of questions for a selected invited speaker, and subsequent submission of protocol about the content of the talk and the discussion

In addition, students will have to pass a written test at the end of the course in order to obtain 3 credit points in the ECTS System. In the final mark (a) will have a weight of 40% and (b) 60%.

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The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver roos (oliver.roos@sipo.gess.ethz.ch).

The course will be supported by an e-learning environment.
Conflict Research I: Political Violence

Abstract
Introduction to research on political violence in domestic and international politics. This course covers the causes and solutions to different types of political violence including interstate wars, civil wars, terrorism or social protests.

Objective
Knowledge on different types of political violence and their causes.

Content
This course offers an introduction to research on the causes and solutions to political violence in domestic and international politics. First, we discuss the definitions and concepts used in conflict research, the data and methods commonly applied and their historical development. Second, we focus on interstate wars und examine in this context state formation, nationalism and democracy. The third part of the course focuses on different types of political violence, including civil war, terrorism or social protests.

Prerequisites / notice
The course «Conflict Research II» in the following semester further examines civil wars.

European Integration (Seminar without Tutorial)

Abstract
The lecture course covers the theory, development, and core policy fields of European integration as well as structures and processes of the EU as a decision- and policy-making system.

Objective
The seminar is designed to help students understand the European Union as a particular kind of political system that differs both from the nation-state and from other international organizations. It imparts basic knowledge on the development, institutions, procedures, and policies of the EU and provides an introduction to major approaches to integration theory and political science research on the EU.

Content
1. Introduction
2. Theories of European integration
3. Institutional development of European integration
4. Development of political integration
5. Internal market and monetary union
6. Internal and external security policies
7. Constitutionalization
8. Widening and differentiation
9. European integration in crisis
10. Institutions
11. Law-making and law enforcement
12. Statehood and democracy
13. Switzerland, the EEA and Neighbourhood Policies

Literature
Die Literatur wird auf Moodle bereitgestellt.

Prerequisites / notice
The grade is based on a written exam.
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3).

There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Lecture notes
Reading materials and slides will be available via Moodle.

Literature
Reading materials and slides will be available via Moodle.

Prerequisites / notice
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There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

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<td>853-0061-00L</td>
<td>Introduction to Cybersecurity Politics</td>
<td>3</td>
<td>W</td>
<td>M. Dunn Cavelty, F. J. Egloff</td>
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<tr>
<td>853-8002-00L</td>
<td>The Role of Technology in National and International Security Policy</td>
<td>3</td>
<td>W</td>
<td>O. Thränerst, A. Dossi, S.-C. Fischer, M. Leese, N. Masuhr</td>
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<tr>
<td>851-0650-00L</td>
<td>AI4Good</td>
<td>3</td>
<td>W</td>
<td>J. D. Wegner</td>
</tr>
</tbody>
</table>
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python)
Support and Diagnosis of Knowledge Acquisition Processes (EW3)

Enrolment only possible with matriculation in Teaching Diploma (except for students of Sport Teaching Diploma, who complete the sport-specific course unit EW3) and for students who intend to enrol in the "Teaching Diploma".

Prerequisites: successful participation in 851-0240-00L "Human Learning (EW1)".

Abstract

In this seminar students learn advanced techniques to support and to diagnose knowledge acquisition processes in school.

Objective

The main goals are:

(1) You have a deep understanding about the cognitive mechanisms of knowledge acquisition.
(2) You have a basic understanding about psychological test theory and can appropriately administer tests.
(3) You know various techniques of formative assessment and can apply these to uncover students' misconceptions.

851-0252-01L

Human-Computer Interaction: Cognition and Usability

Number of participants limited to 35.

Particularly suitable for students of D-ARCH, D-INFK, D-ITET

Abstract

This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.

Objective

This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

851-0252-12L

The Science of Learning from Failure

Number of participants limited to 60.

Abstract

We can learn from failure. But, what does “failure” mean? And, what, how, and why do we learn from failure? This course covers research from the cognitive, educational, and learning sciences that addresses the role of failure in human learning. Students will critically examine how failure affects thinking, knowledge, creativity, problem-solving, and motivation.

Objective

Students will:
- Critically read and analyze articles on research that addresses failure in learning
- Participate in in-class problem-solving activities around research in failure
- Discuss and reflect upon topics in both online and face-to-face formats
- Engage in activities through the online platform
- Complete a final paper on a subtopic related to failure in learning

By the end of the course, students should be able to:
- Demonstrate a critical understanding of the role that failure plays in learning
- Discuss how and why failure can benefit learning
- Discuss how and why failure does not facilitate learning
- Apply understanding to a related sub-topic

Content

We learn from our mistakes, or rather, we hope that we do. Another way to say this is that we can learn from failure. But, what does “failure” mean? What, how, and why do we learn from failure? This course covers research from the cognitive, educational, and learning sciences that addresses the role of failure in human learning. Students will critically examine how failure affects development of knowledge, potential relationships between the facets around failure within individual, interactional, cultural, societal, and global contexts through seminal readings and problem-solving activities. Students from any discipline are welcome to this course to learn more about how failure can be harnessed to improve our knowledge, capabilities, innovations, teamwork, and contribute to the larger global world.

Prerequisites / notice

This seminar is an interactive course, thus attendance and classroom participation are required. Processing of online tasks is a requirement for obtaining credit points.

The course is held as 2 separate courses with each a maximum of 30 students: one course in German and one course in English.

Fostered competencies

- Subject-specific Competencies
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed
- Method-specific Competencies
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Media and Digital Technologies: assessed
  - Problem-solving: assessed
  - Project Management: assessed
- Social Competencies
  - Communication: assessed
  - Cooperation and Teamwork: not assessed
  - Customer Orientation: not assessed
  - Leadership and Responsibility: not assessed
  - Self-presentation and Social Influence: not assessed
  - Sensitivity to Diversity: not assessed
  - Negotiation: not assessed
- Personal Competencies
  - Adaptability and Flexibility: not assessed
  - Creative Thinking: assessed
  - Critical Thinking: assessed
  - Integrity and Work Ethics: not assessed
  - Self-awareness and Self-reflection: assessed
  - Self-direction and Self-management: not assessed
Using uncertainty management by organizations and individuals as conceptual framework, risk management and risk implications of new technologies are treated. Three components of risk management (risk identification/evaluation, risk mitigation, risk communication) and underlying psychological and organizational processes are discussed, using company case studies to promote in-depth understanding.

**Objective**
- You know how risk and risk management is defined and applied in different industries
- You know the challenges of decision making under risk and uncertainty and its effects on organizations
- Know about and (partially) apply some risk management tools
- Gain some more in-depth knowledge in a selected field within risk management through the semester project (e.g. transport systems, IT, insurance)

This course consists of three main elements:

A) Attendance of lectures that provide the theoretical foundations of “Psychological Aspects of Risk Management and Technology” together with reading assignments for each lecture.

B) Attendance of guest lectures that provide a rich source of practical insights and enable the transfer of theory into practice by discussing real-life cases with experts from various industries.

C) Furthermore, this course enables you to apply what you have learned in the classroom into practice by participating in a group assignment in which you gain insights into various risk industries (e.g., aviation, healthcare, insurance) and topics (e.g., risks in cyber-attacks, mountaineering, autonomous vehicles). These projects help students understand key aspects through in-depth application of the course material on real-life topics. Each group project will be mentored and graded by one of the lecturers (70% of course grade). To round off the course at the end of the year, you will have the opportunity to present your group’s findings to the lecturers and to your peers (30% of course grade).

**Content**
The course is organized into fourteen sessions. Sessions comprise a mixture of (guest) lectures, case discussions, and presentations. Through class discussion we will further deepen understanding of the topics and themes of the class. For each session you are required to prepare by reading the assigned literature or case material provided on the Moodle e-learning platform. Topics covered include:

- Elements of risk management:
  - Risk identification and evaluation
  - Risk mitigation
  - Risk communication

- Psychological and organizational concepts relevant in risk management
  - Decision-making under uncertainty
  - Risk perception
  - Resilient organizational processes for managing uncertainty

- Case studies on different elements of risk management (e.g., rule-making, training, managing project risks, automation)

**Lecture notes**
There is no script, but slides will be made available before the lectures.

**Literature**
There are texts for each of the course topics made available before the lectures.

**Prerequisites / notice**
The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).

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**Psychology**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>Period</th>
<th>Language</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>701-0721-00L</td>
<td>This course provides an introduction to psychological research and modelling, focusing on cognitive psychology and the psychological experiment. Participants learn to formulate problems for psychological investigation and apply basic forms of psychological experiment.</td>
<td>W: 3 credits 2V</td>
<td>Autumn Semester 2022</td>
<td></td>
<td>The course is restricted to 40 participants who will work closely with the lecturers on case studies prepared by the lecturers on topics relevant in their own companies (SWICA, SWISS, University Hospital Zurich).</td>
</tr>
</tbody>
</table>

**Evidence-Based Design: Methods and Tools for Evaluating Architectural Design**

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<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>Period</th>
<th>Language</th>
<th>Prerequisites / notice</th>
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<tbody>
<tr>
<td>851-0252-08L</td>
<td>Evidence-Based Design: Methods and Tools for Evaluating Architectural Design</td>
<td>W: 3 credits 2S</td>
<td>Autumn Semester 2022</td>
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**Consciousness Studies**

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<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
<th>Period</th>
<th>Language</th>
<th>Prerequisites / notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0253-07L</td>
<td>Consciousness Studies</td>
<td>W: 2 credits 2V</td>
<td>Autumn Semester 2022</td>
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Number of participants limited to 65.

M. Gath Morad, R. Hansmann, A. Bearth, M. Siegrist

L. Narvaez Zertuche, C. Veddeler
The study of consciousness involves scholars from diverse fields, such as psychology, neuroscience, cognitive science, philosophy, linguistics, computer science, medicine, religious studies, anthropology, as well as literature and art studies. While the study of consciousness is presented mainly from the point of view of psychology in this course, additional interdisciplinary viewpoints are also integrated.

Psychological consciousness studies involve research on levels and states of consciousness. Psychologically researched levels of consciousness are the conscious, preconscious, unconscious/subconscious, and nonconscious levels of mental processing. Psychological research on states of consciousness – which is the main focus of this course – takes waking consciousness as the most common state (ordinary state of consciousness, OSC), using it as a baseline against which altered states of consciousness (ASCs) are compared. Some of the most prominently or promising researched ASCs in psychology will be introduced in this course and include sleeping/dreaming, hypnosis, meditation, sensory deprivation (e.g., floating tank), rhythm-induced trance, as well as ASCs induced by psychoactive drugs (classic psychedelics, dissociative anesthetics, empathogens). Furthermore, it will also be shown how a growing number of health and clinical studies investigate the therapeutic potential of being temporarily in an ASC. Finally, in this course, two mental phenomena that are also highly relevant for the scientific mind – insight and flow – are also introduced from a consciousness-studies perspective.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Semester</th>
<th>Instructor(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0252-02L</td>
<td>Introduction to Cognitive Science</td>
<td>3</td>
<td>W</td>
<td>C. Hölscher</td>
</tr>
<tr>
<td>851-0253-08L</td>
<td>Advanced Topics in Evidence-Based Design for Architecture</td>
<td>3</td>
<td>W</td>
<td>C. Hölscher, M. Gath Morad</td>
</tr>
<tr>
<td>851-0252-60L</td>
<td>Informal Learning Spaces</td>
<td>3</td>
<td>W</td>
<td>C. Hölscher</td>
</tr>
<tr>
<td>851-0345-00L</td>
<td>A Seminar Cycle on Africa</td>
<td>3</td>
<td>W</td>
<td>A. Mabanckou</td>
</tr>
</tbody>
</table>

Objective

Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.

Objective

Students will build on their previous projects as part of the course "Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University Designing the post-pandemic hospital with evidence. for people. The course is funded by an ETH innovedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

Abstract

This course is for D-ARCH students taking the Informal Learning Spaces Design Studio. Students develop their studio project to gain a better understanding of how users behave in that space. Supported by a theoretical foundation in spatial cognition, students observe, analyse and document how their case study is used by others.

Content

What makes a good learning space? How does this differ for students from different disciplines? This interdisciplinary seminar addresses the design of learning spaces by combining methods from architecture and psychology.

Prerequisites / notice

Access to the course is restricted to D-ARCH students of the Informal Learning Spaces Design Studio.
In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called "littérature nègre", which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the "négritude", this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d'Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the 'immigration novel'.

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbuguar Sarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of "ghettoization". African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of "Noirs en France"
On January 18, 2022, the documentary "Noirs en France" (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the "question of being black" still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary "Noirs en France".

NB.
The names of the guests in the seminars might change.

Law

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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</thead>
<tbody>
<tr>
<td>851-0735-09L</td>
<td>Workshop &amp; Lecture Series on the Law &amp; Economics of Innovation</td>
<td>W</td>
<td>2 credits</td>
<td>2S</td>
<td>S. Bechtold</td>
</tr>
</tbody>
</table>

Abstract
This series is a joint project by ETH Zurich and the Universities of St. Gallen and Zurich. It provides an overview of interdisciplinary research on intellectual property, innovation, antitrust, privacy & technology policy. Scholars from law, economics, management and related fields present their current research. All speakers are internationally well-known experts from Europe, the U.S. & beyond.

Objective
After the workshop and lecture series, participants should be acquainted with interdisciplinary approaches towards intellectual property, innovation, antitrust, privacy and technology policy research. They should also have an overview of current topics of international research in these areas.

Content
The workshop and lecture series will present a mix of speakers who represent the wide range of current social science research methods applied to intellectual property, innovation, antitrust, privacy and technology policy issues. In particular, theoretical models, empirical and experimental research as well as legal research methods will be represented.

Literature

<table>
<thead>
<tr>
<th>Lecture notes</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Suzanne Scotchmer, Innovation and Incentives, 2004</td>
</tr>
<tr>
<td></td>
<td>Bronwyn Hall / Nathan Rosenberg (eds.), Handbook of the Economics of Innovation, 2 volumes, Amsterdam 2010</td>
</tr>
<tr>
<td></td>
<td>Bronwyn Hall / Dietmar Harhoff, Recent Research on the Economics of Patents, 2011</td>
</tr>
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</table>

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tbody>
<tr>
<td>Concepts and Theories</td>
<td>Analytical Competencies</td>
<td>Communication</td>
<td>Creative Thinking</td>
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851-0703-00L Introduction to Law

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<th>Number</th>
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<th>Hours</th>
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<tr>
<td>851-0703-00L</td>
<td>Introduction to Law</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>O. Streiff Gnopff</td>
</tr>
</tbody>
</table>
Students who have attended or will attend the lecture “Introduction to Law for Civil Engineering and Architecture” (851-0703-03L) or “Introduction to Law” (851-0708-00L), cannot register for this course unit.

Particularly suitable for students of D-ARCH, D-MAVT, D-MATL

Abstract
This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

Objective
Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

Content
Basic concepts of law, sources of law.
Private law: Contract law (particularly contract for work and services), tort law, property law.
Public law: Human rights, administrative law, procurement law, procedural law.
Insights into the law of the EU and into criminal law.

Lecture notes
Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

851-0742-00L Contract Design I
This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Abstract
Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Objective
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.
2) You have to take computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Handouts, prerecorded videos, slides, and other materials

Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Prerequisites / notice
Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-MAVT, D-MATL.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Negotiation assessed

Personal Competencies
Creative Thinking assessed

851-0703-04L Law and Urban Space

Particularly suitable for students of D-ARCH
Abstract
Legal rules are tied to urban space. Illustrative is the relation between land ownership and urban morphology or between zoning and the functional dimension of urban space. Legal concepts (from property law, fundamental rights and administrative law) with spatial impacts are introduced and related to the theory of urban design. Moreover, it is discussed how these concepts shape specific places.

Objective
Students recognize the interplay between legal structures and urban space. They can describe legal concepts with spatial impact. Moreover, they are able to compare legally binding targets with theoretical approaches in urban design. By analysing specific places, students learn to find relevant norms, to analyse and to judge them with regard to urban design theories. Thereby, they are able to distinguish design and policy questions.

Content
Using the term «lawscape» (Philippopoulos-Mihalopoulos), we initially discuss general aspects of the interplay between legal rules and urban space.

The first part of the course is about the morphological dimension of urban space. We compare positions of urban planners like Trancik (Finding Lost Space) or Rowe/Koetter (Collage City) with property law. Freedom of property in turn contrasts to the theoretical approaches of Bernoulli (Die Stadt und ihr Boden) or Rossi (L’architettura della città). Using court decisions concerning nail houses, we study the tensions between urban development and the system of property ownership.

In the third part of the course, we work on the social, visual and temporal dimensions of urban space. The positions of Jacobs (The Death and Life of Great American Cities), Cullen (Townscape) or Lynch (The Presence of the Past) are compared with the dichotomy public space/private space, safety regulations, regulations on design reviews or heritage protection laws.

Working tools are theoretical texts, legal rules, court decisions as well as site analyses. Students undertake a case study in small groups. Selected case studies are presented and discussed in a final meeting.

Prerequisites / notice
851-0707-00L 851-0709-00L

Lecture notes
See Literature.

Literature
Documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17513).

Prerequisites
Number of participants limited to: 45

851-0727-00L

E-Business-Law
Particularly suitable for students of D-INFK, D-ITET

Abstract
The course deals with the basic legal framework for doing e-business as well as using information technology. It discusses a variety of legal concepts and rules to be taken into account in practice, be it when designing and planning new media business models, be it when implementing online projects and undertaking information technology activities.

Objective
The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.
The students shall obtain the following competence:

Concepts and Theories
- assessed
2 credits

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Law for Entrepreneurs
W 2 credits 2V  P. Peyrot
851-0735-010L

Particularly suitable for students of D-ITET, D-MAVT

Number of participants limited to 100

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

Abstract

Objective
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

Lecture notes
A comprehensive script will be made available online on the moodle platform.

Intellectual Property: Introduction
W 2 credits 2V  M. Schweizer
851-0738-000L

Particularly suitable for students of D-CHAB, D-INFK, D-ITET, D-MAVT, D-MATL, D-MTEC

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

Abstract

Objective
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

The Role of Intellectual Property in the Engineering and Technical Sector
W 2 credits 2V  K. Houshang Pour Islam
851-0738-010L

Particularly suitable for students of D-BAUG, D-BIOL, D-BSSE, D-CHAB, D-ITET, D-MAVT

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

### Building a Robot Judge: Data Science for Decision-Making (Course Project)

**Abstract**

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

**Objective**

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

**Content**

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

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**851-0750-00L**  
**Building a Robot Judge: Data Science for Decision-Making**  
Particularly suitable for students of D-INFK, D-ITET, D-MTEC

**Abstract**

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

**Objective**

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

**Content**

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

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**851-0761-00L**  
**Building a Robot Judge: Data Science for Decision-Making (Course Project)**  
This is the optional course project for "Building a Robot Judge: Data Science for the Law."

**Abstract**

Please register only if attending the lecture course or with consent of the instructor.

Some programming experience in Python is required, and some experience with text mining is highly recommended.

**Objective**

Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

**Content**

Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models.

We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.

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**851-0742-01L**  
**Contract Design II**

Does not take place this semester.

This course is taught by Professor Alexander Stremitzer ([https://lawecon.ethz.ch/group/professors/stremitzer.html](https://lawecon.ethz.ch/group/professors/stremitzer.html)). To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

**Abstract**

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

**Objective**

There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer's Teaching Assistant Diego Caldera ([diegoalberto.calderaherrera@uzh.ch](mailto:diegoalberto.calderaherrera@uzh.ch)).

**Prerequisites / notice**

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

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**851-0724-01L**  
**Real Estate Property Law**

Particularly suitable for students of D-ARCH, D-BAUG, D-
USYS

Abstract
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

Objective
The legal principles of real estate property law can be correctly interpreted and applied in daily life.

Content
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

Lecture notes
Abgegebene Unterlagen: Skript in digitaler Form

Literature
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationssystemrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

Fostered competencies

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<thead>
<tr>
<th>Subject-specific Competencies</th>
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| Personal Competencies        | Adaptability and Flexibility | not assessed |
|                              | Creative Thinking          | assessed |
|                              | Critical Thinking          | assessed |
|                              | Integrity and Work Ethics  | assessed |
|                              | Self-awareness and Self-reflection | assessed |
|                              | Self-direction and Self-management | not assessed |

851-0732-06L Law & Tech

Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/s/o7dttHXV5jAI9CE) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

Abstract
This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective
The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content
The planned course outline is below
1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

851-0252-10L Sociology

Abstract
In this seminar, students will study cognitive processes, behaviour and the underlying biological response to financial decisions. Research methods such as asset market experiments, lottery games, risk preference assessment, psychometrics, neuroimaging and psychophysiology of decision processes will be discussed. Financial bubbles and crashes will be the core interest.
This course has four main goals:
1) To learn about the most important topics within Behavioural Finance
2) To learn how to conduct behavioural studies, design experiments, plan data collection and experimental tasks
3) To learn about causes of market crashes, factors that influence them, traders' behaviour before, during and after financial crises
4) To investigate a topic of interest, related to behaviour of traders during market crashes.

Additionally, the course gives to the students the opportunity to practice oral presentations, communication skills, report writing and critical thinking.

The course provides an overview of the most important topics in Behavioural Finance. First part of the course involves reading scientific articles, which will be discussed during the seminar. Therefore, attendance is required to pass the course. Each week, a student volunteer will present a paper and the presentation will be followed by a discussion. After obtaining sufficient knowledge of the field, students will select a topic for a behavioural study of their own. The final assignment consists of preparing and conducting a small behavioural study/experiment, analysing the data and presenting the project in the final meeting of the class. Each student will write a scientific report of their study.

Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and tests those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and develop an understanding of how those can be fit to empirical data. This will enable students to independently address research questions from various social science fields.

The following topics will be covered:

- Introduction to network models and their applications
- Stylized models:
  * uniform random graph models
  * small world models
  * preferential attachment models
- Models for testing hypotheses while controlling for the network structure:
  * Quadratic assignment procedure regression (QAP regression)
- Models for testing hypotheses on the network structure:
  * Models for one single observation of a network: exponential random graph models (ERGMs)
  * Models for panel network data: stochastic actor-oriented models (SAOMs)
  * Models for relational event data: dynamic network actor models (DyNAMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes
Slides and lecture notes are distributed via the associated course moodle.


Literature
- Cohesion
- Roles
- Centrality
- Macro and Micro Structure
- Empirical Research and Network Data
- Preferential Attachment Models
- Small World Models
- Uniform Random Graph Models
- Quadratic Assignment Procedure Regression

Prerequisites / notice
Students are required to have basic knowledge in inferential statistics, such as regression models.

Network Analysis is a distinct domain of data science that is characterized by a specific kind of data being studied. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

- Empirical Research and Network Data
- Macro and Micro Structure
- Centrality
- Roles
- Cohesion
- Preferential Attachment Models
- Small World Models
- Uniform Random Graph Models
- Quadratic Assignment Procedure Regression

Lecture notes
Lecture notes are distributed via the associated course moodle.


Computational Social Science

Number of participants limited to 40.
Abstract
The seminar aims at three-fold integration: (1) bringing modeling and computer simulation of techno-socio-economic processes and phenomena together with related empirical, experimental, and data-driven work, (2) combining perspectives of different scientific disciplines (e.g., sociology, computer science, physics, complexity science, engineering), (3) bridging between fundamental and applied work.

Objective
Participants of the seminar should understand how tightly connected systems lead to networked risks, and why this can imply systems we do not understand and cannot control well, thereby causing systemic risks and extreme events.

They should also be able to explain how systemic instabilities can be understood by changing the perspective from a component-oriented to an interaction- and network-oriented view, and what fundamental implications this has for the proper design and management of complex dynamical systems.

Computational Social Science and Global Systems Science serve to better understand the emerging digital society with its close co-evolution of information and communication technology (ICT) and society. They make current theories of crises and disasters applicable to the solution of global-scale problems, taking a data-based approach that builds on a serious collaboration between the natural, engineering, and social sciences, i.e. an interdisciplinary integration of knowledge.

Literature
Computational Social Science
https://science.sciencemag.org/content/sci/323/5915/721.full.pdf

Manifesto of Computational Social Science
https://link.springer.com/article/10.1140/epjst/e2012-01697-8

Social Self-Organisation

How simple rules determine pedestrian behaviour and crowd disasters
https://www.pnas.org/content/108/17/6884.short

Peer review and competition in the Art Exhibition Game
https://www.pnas.org/content/113/30/8414.short

Generalized network dismantling
https://www.pnas.org/content/116/14/6554.short

Computational Social Science: Obstacles and Opportunities
https://science.sciencemag.org/content/369/6507/1060?rss=1=

Bit by Bit: Social Research in the Digital Age
https://www.amazon.co.uk/Bit-Social-Research-Digital-Age-ebook/dp/B072MPFXZ2/

Further literature will be recommended in the lectures.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Prerequisites / notice
Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Fostered competencies

Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making not assessed
- Media and Digital Technologies not assessed
- Problem-solving not assessed
- Project Management not assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork not assessed
- Customer Orientation not assessed
- Leadership and Responsibility not assessed
- Self-presentation and Social Influence assessed
- Sensitivity to Diversity not assessed
- Negotiation not assessed

Personal Competencies
- Adaptability and Flexibility not assessed
- Creative Thinking assessed
- Critical Thinking assessed
- Integrity and Work Ethics assessed
- Self-awareness and Self-reflection assessed
- Self-direction and Self-management assessed

851-0586-03L Applied Network Science: Social Media Networks
W 3 credits 2S U. Brandes

We study applications of network science methods, this semester in the domain of social media. Topics are selected for diversity in research questions and techniques for topics such as privacy and information spread on a variety of platforms. Student teams present results from the recent literature, possibly with replication, in a one-day conference.

Objective
Network science as a paradigm is entering domains from engineering to the humanities but application is tricky. By examples from recent research on social media, students learn to appreciate that, and how, context matters. They will be able to assess the appropriateness of approaches for substantive research problems, and especially when and why quantitative approaches are or are not suitable.

851-0745-00L Ethics Workshop: The Impact of Digital Life on Society
W 2 credits 2S E. Vayena, A. Blasimme, A. Ferretti, C. Landers, J. Sleigh

Abstract
Open to all Master level / PhD students.

This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.
Objective
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.

Content
The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored. Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

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851-0253-08L Advanced Topics in Evidence-Based Design for Architecture
Course requirements: Completion of the course Evidence-Based Design: Methods and Tools For Evaluating Architectural Design (851-0252-08L)

Abstract
Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.

Objective
Students will build on their previous projects as part of the course "Evidence-Based Design: Methods and Tools For Evaluating Architectural Design" (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University Designing the post-pandemic hospital with evidence. for people. The course is funded by an ETH innoedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

851-0101-86L Complex Social Systems: Modeling Agents, Learning, and Games
Number of participants limited to 100.
Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract
This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective
The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Content
Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lecture notes
The lecture slides will be presented on the course web page after each lecture.
<table>
<thead>
<tr>
<th>Literature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agent-Based Modeling</td>
<td><a href="https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2">https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2</a></td>
</tr>
<tr>
<td>Traffic and related self-driven many-particle systems</td>
<td>Reviews of Modern Physics 73, 1067</td>
</tr>
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<td></td>
<td><a href="https://journals.aps.org/revmodphys/abstract/10.1103/RevModPhys.73.1067">https://journals.aps.org/revmodphys/abstract/10.1103/RevModPhys.73.1067</a></td>
</tr>
<tr>
<td>Pedestrian, Crowd, and Evacuation Dynamics</td>
<td><a href="https://www.research-collection.ethz.ch/handle/20.500.11850/45424">https://www.research-collection.ethz.ch/handle/20.500.11850/45424</a></td>
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<tr>
<td>The hidden geometry of complex, network-driven contagion phenomena</td>
<td>(relevant for modeling pandemic spread)</td>
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<tr>
<td></td>
<td><a href="https://science.sciencemag.org/content/342/6164/1337">https://science.sciencemag.org/content/342/6164/1337</a></td>
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</table>

Further literature will be recommended in the lectures.

Prerequisites / notice

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

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<tr>
<th>851-0467-00L From Traffic Modeling to Smart Cities and Digital Democracies</th>
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<td>W 3 credits 2S D. Helbing, S. Mahajan</td>
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Abstract

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

Objective

To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

Content

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Prerequisites / notice

Further literature will be recommended in the lectures.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2354 of 2416
Through this cycle of seminars, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation.

Learning Objectives:
- Know the most relevant social network terminology and concept
- Know the most relevant sociological and psychological social network theories
- Know the most relevant methods to study online and offline behavior
- Be able to develop meaningful social networks research questions
- Be able to design your own social networks study
- Critically examine empirical research in the field of (online) social networks

The digital transformation has made the “online world” increasingly important for the “offline world”. Hence, interactions in online social networks ultimately affect how people feel, think, behave and interact in offline settings. This course aims to present and structure open debates in online and offline social network research with a focus on social network processes, individual outcomes, and emergent phenomena. By taking a social networks perspective, we view individuals and their behavior in online and offline settings as part of a larger social environment and social phenomena as emerging from interrelated social behavior.

Number of participants limited to 30

Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon’s central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

Please visit our website: https://participatoryresilience.ch/

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.
In seminar cycle, we will conduct a journey through black African literature written in French, from its origins to its main subjects, including the western perception of this literary creation. This will lead, at the end of the cycle, to wider perspectives, such as the questions that arise today, on the presence of Black people in France - and beyond - in Europe. (More information on: https://francais.ethz.ch/)

Friday, November 11th
9:30 a.m. - 12:30 p.m.
Lesson 1: The origins of French-speaking African literature
French colonial literature gave birth to the so-called “littérature ‘nègre’”, which would later claim a word that was forbidden or confiscated by the West, allowed sometimes under the guardianship or under the cover of a certain cultural alienation, until the frank rupture born with the “négritude”, this current that, in the interwar period, exalted the pride of being black and the heritage of African civilizations.

2:00 pm - 4:30 pm
Seminar 1:
Guest Sami Tchak, Togolese writer, Grand Prix littéraire d’Afrique noire

Friday, November 18th
9:30 a.m.-12:30 p.m.
Lesson 2: Themes of contemporary African literature
This will be an evocation of the major subjects of the African novel, including the pre-colonial period, the colonial painting, the illusions of the African independence and especially the birth of the ‘immigration novel’.

2:00 - 4:30 pm
Seminar 2:
Guest Mohamed Mbougar Sarr, Senegalese writer, Prix Goncourt

Friday, November 25th
9:30 a.m.-12:30 p.m.
Lesson 3: On the Western perception of African literature
The representation and popularization of African literature in the West sometimes undergoes a kind of “ghettoization”. African literature is then perceived as a distant island. Western publishers, as well as literary critics, compete for ingredients that would illustrate Africa according to them and that they expect from authors of the African continent. One finds traces of this trend even on the covers of books.

2:00 - 4:30 pm
Seminar 3: Guest Charlyne Effa, Gabonese novelist

Friday, December 16th
9:30am-12:30pm
Lesson 4: From Africa to France: Screening of “Noirs en France”
On January 18, 2022, the documentary “Noirs en France” (Black people in France), which I co-wrote with Aurélia Perreau, was screened in France on the France 2 channel. The success of this work illustrates how much the “question of being black” still remains a taboo subject. This is an opportunity to screen this film and to open the discussion with the authors.

2:00 pm - 4:30 pm
Seminar 4:
Guest Aurélia Perreau, co-author of the documentary " Noirs en France ".

NB.
The names of the guests in the seminars might change.

Science Research

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
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<tbody>
<tr>
<td>851-0020-00L</td>
<td>Gender and Science</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>N. El Kassar, C. L. Blaser</td>
</tr>
<tr>
<td>Abstract</td>
<td>This lecture series offers an introduction to the relationship between gender and science, with a focus on the specific intersections with the sciences taught at ETH.</td>
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<tr>
<td>Objective</td>
<td>This lecture series is designed to acquaint students from all levels and departments with the various ways in which gender perspectives matter for specific scientific disciplines, as well as for science in general. Students will learn to recognize and analyse the specific ways in which scientific theories and methods are gendered. They will be able to discuss and reflect how these topics are connected to their own scientific disciplines.</td>
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<tr>
<td>Content</td>
<td>There is agreement across academic disciplines today that gender influences and structures the production of knowledge and that scientific knowledge production in turn shapes gender notions. Even within “hard” sciences such as mathematics, physics, engineering, etc., gender is a significant factor in determining what counts as “objective” knowledge, who can know it, what kind of knowledge is produced, or how this knowledge is acquired and justified. Feminist research aims to reveal how dominant conceptions of science and knowledge practices disadvantage women, and other subordinate groups, within the field of Gender and Science. An important part of feminist critique is to show that such efforts substantially improve the overall quality of research. The semester will start with two introductory lectures acquainting students with research questions in the field of Gender and Science by summarizing its key concepts and methods. It will then continue as a series of weekly guest lectures by scholars from different scientific disciplines that provide accessible insights into the intersection between gender studies and the guest lecturer’s research field. Students will thereby be encouraged to learn from concrete examples rather than abstract theory. The goal is for students to understand how to apply concepts and methods of gender studies to their particular disciplines. Intermediate discussions with the students will provide a forum for critically reflecting the content of the lectures and the connections to their own academic fields and practices.</td>
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<td></td>
<td>All lectures by the guest speakers will also be open to the broader ETH public, while the introductory and discussion sessions are only for registered course participants.</td>
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</table>

851-0184-00L | Pluralist Philosophy of Mathematics | W    | 3    | 2V    | R. Wagner |
| Abstract     | This course will follow Michèle Friend's book "pluralism in mathematics". It will survey various mainstream philosophies of mathematics, and suggest a pluralist integration. |
| Objective    | The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions. |
The course will examine realist, constructivist, structuralist and formalist philosophies of mathematics, and follow Friend in suggesting a pluralist approach that combines the various positions based on our agnosticism as to the best philosophy and a paraconsistent approach to philosophical logic. In this course we will learn the various positions, critically evaluate Friend's arguments, and consider the general merits and limitations of pluralist and paraconsistent philosophical approaches.

### Fostered competencies

- **Subject-specific Competencies**: Concepts and Theories assessed
- **Method-specific Competencies**: Analytical Competencies assessed
- **Personal Competencies**: Critical Thinking assessed

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**Type B: Reflection About Subject-Specific Methods and Contents**

Subject-specific courses. Particularly relevant for students interested in those subjects.

All these courses are also listed under the category “Typ A”, and every student can enroll in these courses.

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**D-ARCH**

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
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<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0703-00L</td>
<td>Introduction to Law</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>O. Streiff Gnöpff</td>
</tr>
</tbody>
</table>

Students who have attended or will attend the lecture “Introduction to Law for Civil Engineering and Architecture” (851-0703-03L) or “Introduction to Law” (851-0708-00L), cannot register for this course unit.

- Particularly suitable for students of D-ARCH, D-MAVT, D-MATL

**Abstract**

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.

**Objective**

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

**Content**

- Private law: Contract law (particularly contract for work and services), tort law, property law.
- Public law: Human rights, administrative law, procurement law, procedural law.
- Insights into the law of the EU and into criminal law.

**Lecture notes**

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

**Literature**

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

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**Contract Design I**

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<tr>
<th>Number</th>
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<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tr>
<td>851-0742-00L</td>
<td>Contract Design I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Stremitzer</td>
</tr>
</tbody>
</table>

This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

**Abstract**

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

**Objective**

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

**ETH students**: Your grade will consist of two parts:

1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.

2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

**Lecture notes**

Handouts, prerecorded videos, slides, and other materials
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). The seminar will provide an opportunity to experience some of the methods in applied group projects.

The objective of the seminar is to enable students to approach a human-computer interaction setting through a holistic and theoretical perspective. Students learn to find relevant norms, to analyse and to judge them with regard to urban design theories. Thereby, they are able to distinguish design and policy questions.

Content
Using the term «lawscape» (Philippopoulos-Mihalopoulos), we initially discuss general aspects of the interplay between legal rules and urban space. Legal rules are tied to urban space. Illustrative is the relation between land ownership and urban morphology or between zoning and the functional dimension of urban space. Legal concepts (from property law, fundamental rights and administrative law) with spatial impacts are introduced and related to the theory of urban design. Moreover, it is discussed how these concepts shape specific places.

The first part of the course is about the morphological dimension of urban space. We compare positions of urban planners like Trancik (Finding Lost Space) or Rowe/Koetter (Collage City) with property law. Freedom of property in turn contrasts to the theoretical approaches of Bernoulli (Die Stadt und ihr Boden) or Rossi (L'architettura della città). Using court decisions concerning nail houses, we study the tension between urban development and the system of property ownership.

In the third part of the course, we work on the social, visual and temporal dimensions of urban space. The positions of Jacobs (The Death and Life of Great American Cities), Cullen (Townscape) or Lynch (The Presence of the Past) are compared with the dichotomy public space/private space, safety regulations, regulations on design reviews or heritage protection laws.

Working tools are theoretical texts, legal rules, court decisions as well as site analyses. Students undertake a case study in small groups. Selected case studies are presented and discussed in a final meeting.

Prerequisites
Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gerick (lucas.gerick@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Lecture notes
See Literature

Prerequisites / notice
Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories assessed
- Techniques and Technologies assessed

Method-specific Competencies
- Analytical Competencies assessed
- Decision-making assessed
- Problem-solving assessed

Social Competencies
- Communication assessed
- Cooperation and Teamwork assessed
- Customer Orientation assessed
- Negotiation assessed

Personal Competencies
- Creative Thinking assessed

Literature
Documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17513).

Number of participants limited to: 45

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 2358 of 2416
Evidence-Based Design: Methods and Tools for Evaluating Architectural Design

Number of participants limited to 40

**Abstract**

Students are taught a variety of analytic techniques that can be used to evaluate architectural design. The concept of evidence-based design is introduced, and complemented with theoretical background on space syntax and spatial cognition. This is a project-oriented course, students implement a range of methods on a sample project. The course is tailored for architecture design students.

**Objective**

The course aims to teach students how to evaluate a design project from the perspective of the end user. The concept of evidence-based design is introduced through a series of case studies. Students are given a theoretical background in space syntax and spatial cognition, with a view to applying this knowledge during the design process. The course covers a range of methods including visibility analysis, network analysis, conducting real-world observations, and virtual reality for architectural design. Students apply these methods to a case study of their choice, which can be at building or urban scale. For students taking a B-ARCH or M-ARCH degree, this can be a completed or ongoing design studio project. The course gives students the chance to implement the methods iteratively and explore how best to address the needs of the eventual end-user during the design process.

The course is tailored for students studying for B-ARCH and M-ARCH degrees. As an alternative to obtaining D-GESS credit, architecture students can obtain course credit in "Vertiefungsfach" or "Wahlfach".

**Real Estate Property Law**

**Abstract**

Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

**Objective**

The legal principles of real estate property law can be correctly interpreted and applied in daily life.

**Content**

Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastre. Basic questions of contract and tax law.

**Literature**

Abgegebene Unterlagen: Skript in digitaler Form
- Wolfgang Ernst / Samuel Zogg: Sachenrecht, Zürich 2020
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

**Subject-specific Competencies**

- Concepts and Theories
- Techniques and Technologies

**Method-specific Competencies**

- Analytical Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management

**Social Competencies**

- Communication
- Cooperation and Teamwork
- Customer Orientation
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation

**Personal Competencies**

- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**From Traffic Modeling to Smart Cities and Digital Democracies**

**Abstract**

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

**Objective**

To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

**Content**

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Literature

Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/281629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future

Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/2020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/686.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective-collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f48e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_1_fkmr1_1?dchild=1&keywords=coordination+Jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Decentralized Collective Learning for Self-managed Sharing Economies
https://dl.acm.org/doi/abs/10.1145/3277668

Further literature will be recommended in the lectures.

Prerequisites / notice

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
**Fostered competencies**

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>Method-specific Competencies</th>
<th>Social Competencies</th>
<th>Personal Competencies</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Communication</td>
<td>Adaptability and Flexibility</td>
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<td>Decision-making</td>
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<td>Integrity and Work Ethics</td>
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<td></td>
<td>Project Management</td>
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<td>Self-awareness and Self-reflection</td>
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</tbody>
</table>

**Course requirements**

- **Contract Design II**
  - Course: Taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).
  - Prerequisites: Must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

**Abstract**

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

**Objective**

There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer's Teaching Assistant Diego Caldera (diegoalberto.calderaherrera@uzh.ch).

**Prerequisites / notice**

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

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**851-0742-01L Contract Design II**

**W** 1 credit 1U A. Stremitzer

Does not take place this semester.

This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).

**Abstract**

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

**Objective**

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**851-0426-00L Paul Feyerabend's Anarchistic Theory of Knowledge**

**W** 3 credits 2S M. Hagner, M. Hampe

**Abstract**

Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

**Objective**

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

**Content**

We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

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**851-0253-08L Advanced Topics in Evidence-Based Design for Architecture**

**W** 3 credits 2U C. Hölscher, M. Gath Morad

**Abstract**

Students will gain advanced knowledge and practical hands-on experience with agent-based simulations and spatial analysis tools to evaluate hospital layouts from the perspective of end-users.

**Objective**

Students will build on their previous projects as part of the course “Evidence-Based Design: Methods and Tools For Evaluating Architectural Design” (851-0252-08L). Students enrolled will participate in an international workshop with GSAPP at Columbia University Designing the post-pandemic hospital with evidence for people. The course is funded by an ETH innoedum project entitled cogARCH: linking cognition and architecture to design resilient hospitals architecture.

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**851-0601-00L Participatory Resilience**

**W** 3 credits 3G D. Helbing, J. Argota Sánchez-Vaquero, C. I. Hausladen, S. Mahajan

**Abstract**

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

**Objective**

The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

**Content**

The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

Please visit our website: https://participatoryresilience.ch/
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

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The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

**Abstract**

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

**Objective**

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

**Topics covered during the lecture will include:**
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

**Prerequisites / notice**

The lecture addresses students in the fields of engineering, science and other related technical fields.

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The lecture addresses students in the fields of engineering, science and other related technical fields.

**Number of participants limited to 160. Max 80 ETHZ and 80 UZH Students**

**Abstract**

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

**ETH students:** Your grade will consist of two parts:

1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.

2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

**Lecture notes**

Handouts, prerecorded videos, slides, and other materials
In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their environmental context. The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

The procedure for accumulating CP will be explained at the start of term.

Prerequisites / notice
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

Global History of Urban Design I

This course focuses on the history of the design of cities, as well as on the ideas, processes and actors that engender and lead their development and transformation. The history of urban design will be approached as a cross-cultural field of knowledge that integrates scientific, economic and technical innovation as well as social and cultural advances.

The lectures deal mainly with the definition of urban design as an independent discipline, which maintains connections with other disciplines (politics, sociology, geography) that are concerned with the transformation of the city. The aim is to make students conversant with the multiple theories, concepts and approaches of urban design as they were articulated throughout time in a variety of cultural contexts, thus offering a theoretical framework for students’ future design work.

In the first semester the genesis of the objects of study, the city, urban culture and urban design, are introduced and situated within their intellectual, cultural and political contexts:

01. The History and Theory of the City as Project
02. Of Rituals, Water and Mud: The Urban Revolution in Mesopotamia and the Indus
03: The Idea of the Polis: Rome, Greece and Beyond
04: The Long Middle Ages and their Counterparts: From the Towns of Tuscany to Delhi
05: Between Ideal and Laboratory: Of Middle Eastern Grids and European Renaissance Principles
06: Of Absolutism and Enlightenment: Baroque, Defense and Colonization
07: The City of Labor: Company Towns as Cross-Cultural Phenomenon
09: Garden Cities of Tomorrow: From the Global North to the Global South and Back Again
010: Civilized Wilderness and City Beautiful: The Park Movement of Olmsted and The Urban Plans of Burnham
011: The Extension of the European City: From the Viennese Ringstrasse to Amsterdam Zuid

851-0707-00L

Space Planning Law and Environment

Particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MAVT, D-MTEC, D-INFK, and D-MATH. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gercke (lucas.gercke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Prerequisites / notice
Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

Fostered competencies
Subject-specific Competencies
- Concepts and Theories
- Techniques and Technologies

Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Negotiation

Personal Competencies
- Creative Thinking

851-0707-00L

Space Planning Law and Environment

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Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

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Subject-specific Competencies
- Concepts and Theories
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Method-specific Competencies
- Analytical Competencies
- Decision-making
- Problem-solving

Social Competencies
- Communication
- Cooperation and Teamwork
- Customer Orientation
- Negotiation

Personal Competencies
- Creative Thinking

701-0703-00L

Environmental Ethics

The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

The procedure for accumulating CP will be explained at the start of term.

Prerequisites / notice
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.
Lecture notes
Prior to each lecture a chapter of the reader (Skript) will be made available through the webpage of the Chair. These chapters will provide an introduction to the lecture, the basic visual references of each lecture, key dates and events, as well as references to the compulsory and additional reading.

Literature
There are three books that will function as main reference literature throughout the course:


These books will be reserved for consultation in the ETH Baubibliothek, and will not be available for individual loans.

Prerequisites / notice
Students are required to familiarize themselves with the conventions of architectural drawing (reading and analyzing plans at various scales).

851-0650-00L
Al4Good m
W 3 credits 2G J. D. Wegner

Abstract
The Al4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content
The Al4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course Al4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0724-01L
Real Estate Property Law
W 3 credits 3V S. Stucki, R. Müller-Wyss

Abstract
Particularly suitable for students of D-ARCH, D-BAUG, D-USYS

Objective
The legal principles of real estate property law can be correctly interpreted and applied in daily life.

Content
Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss). Legal presentation: land register, surveying, cadastr. Basic questions of contract and tax law.

Lecture notes
Abgegebene Unterlagen: Skript in digitaler Form

Literature
- Adrian Mühlematter / Stephan Stucki: Grundbuchrecht für die Praxis, Zürich 2016
- Wolfgang Ernst / Samuel Zogg: Sachenrecht in a nutshell, Zürich 2020
- Jörg Schmid / Bettina Hürlimann-Kaup: Sachenrecht, Zürich 2017
- Meinrad Huser, Schweizerisches Vermessungsrecht, unter besonderer Berücksichtigung des Geoinformationsrecht und des Grundbuchrechts, Zürich 2014
- Meinrad Huser, Geo-Informationsrecht, Rechtlicher Rahmen für Geographische Informationssysteme, Zürich 2005
- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 236 ff.

Fostered competencies
- Concepts and Theories

Method-specific Competencies
- Communication

Social Competencies
- Negotiation
- Adaptable and Flexible

Personal Competencies
- Analytical and Conceptual Competencies
- Decision-making
- Media and Digital Technologies
- Problem-solving
- Project Management
- Cooperation and Teamwork
- Leadership and Responsibility
- Self-presentation and Social Influence
- Sensitivity to Diversity
- Negotiation
- Adaptability and Flexibility
- Creative Thinking
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

A list of further recommended literature will be found within each chapter of the reader (Skript).

851-0742-01L
Contract Design II
W 1 credit 1U A. Stremitzer

Does not take place this semester.

This course is taught by Professor Alexander Stremitzer (https://lawecn.ethz.ch/group/professors/stremitzer.html),

To be considered for Contract Design II, you must have
Paul Feyerabend's Anarchistic Theory of Knowledge

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Lecturers

W.

I. Introduction to Moral Reasoning

We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

851-0426-00L Paul Feyerabend's Anarchistic Theory of Knowledge W 3 credits 2S M. Hagner, M. Hampe

Abstract

Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Content

We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

D-BIOL

Number Title Type ECTS Hours Lecturers

851-0180-00L Research Ethics W 2 credits 2G G. Achermann, P. Emch

Abstract

Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Objective

Participants of the course Research Ethics will

• Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
• Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;

Content

1. Introduction to Moral Reasoning

1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethics: a classification 1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics

2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories 2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma

3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities

1. Integrity in research and research misconduct

1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QDRP/DPR) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management

2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Ownership of data 2.6 Sharing of data 2.7 The ethics of big data

3. Publication ethics / Responsible publishing

3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities

1. Research involving human subjects

1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity

1.5 Selection of study participants – the concept of vulnerability

1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility

2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media 2.3 Public advocacy (policy making)

3. Dual use research

3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.
This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus specifically on the times from antiquity up to the present, particularly on the challenges to current law posed by prominent near-future technologies. The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences. The course will combine both an overview of major areas of law that are relevant for the regulation of state-of-the-art technology and guest lectures on new technological developments.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided. The course Slack workspace will provide information about the assignment and for access to the course Slack workspace.

Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/s/o7dtH4V5A9I9CE) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

The planned course outline is below:

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time) connected with your active participation during class, e.g., taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more...).
Objective

There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

851-0426-00L
Paul Feyerabend's Anarchistic Theory of Knowledge

3 credits
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective

It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Content

We will start this seminar with a close reading of Paul Feyerabend’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

376-1661-00L
Ethics of Life Sciences and Biotechnology

3 credits
This semester course enables students to recognize, anticipate and address ethical issues in the domain of health sciences and their technological application. The students will acquire the necessary theoretical and analytic resources to develop critical thinking skills in the field of applied ethics and will practice how to use such resources to address concrete ethical issues in health sciences.

Objective

This course is tailored to students who want to become familiar with the analysis of ethical issues in all the different domains of life sciences and biotechnology. The course aims at equipping students with the necessary knowledge and analytic skills to understand, discuss and address the ethical aspects of science and technology in the domain of human health. The specific learning objectives of this course are:

- A. Identify ethical issues in life sciences and biotechnology.
- B. Analyze and critically discuss ethical issues in life sciences and biotechnology.
- C. Become aware of relevant legal and public policy frameworks.
- D. Distinguish different ethical approaches and argumentative strategies in applied ethics.
- E. Recognize how ethical issues relate to different accounts of technology and innovation.
- F. Develop a personal and critical attitude towards the ethical aspects of life sciences and their technological application.
- G. Autonomously anticipate ethical issues.
- H. Propose and communicate solutions to ethical challenges and dilemmas.

Content

The course starts off with an introductory lecture on ethics as a discipline and an overview of the most relevant approaches in the domain of applied ethics. The students will also be introduced to current theoretical accounts of technology and will start to appreciate the relevance of ethics especially with respect to new and emerging technologies. Useful analytic tools will also be provided, thus enabling the students to engage with the discipline in a practical way from the very onset of the semester.

The course will continue with thematic sessions covering a broad variety of topics all of which are relevant to the different study tracks offered by the department. In particular, the course will cover the following domains: digital health technologies and medical AI; food, nutrition and healthy longevity; biomedical engineering; genetics; neuroscience and Neurotechnologies; medical robotics; disability and rehabilitation; environmental ethics. The course will also include sessions on cross-cutting ethically relevant aspects of health sciences and technologies, namely: access to innovation, translational research, and the relation between science and public policy.

All the topics of the course will be illustrated and interactively discussed through many case studies, offering the students the opportunity to prepare and present them, and to use them in individual as well as group exercises. Throughout the course, the students will have multiple opportunities to experiment with ethical argumentation and to practice their evolving skills.

D-BSSE

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<thead>
<tr>
<th>Number</th>
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<th>ECTS</th>
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<tbody>
<tr>
<td>851-0738-01L</td>
<td>The Role of Intellectual Property in the Engineering and Technical Sector</td>
<td>W</td>
<td>2 credits</td>
<td>2V</td>
<td>K. Houshang Pour Islam</td>
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Abstract

The lecture offers a brief overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Objective

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

851-0426-00L
Paul Feyerabend’s Anarchistic Theory of Knowledge

3 credits
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

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<td>W</td>
<td>2</td>
<td>2G</td>
<td>G. Achermann, P. Emch</td>
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Number of participants limited to 40

Participants of the course Research Ethics will
• Develop an understanding of the role of certain moral concepts, principles and normative theories related to scientific research;
• Improve their moral reasoning skills (such as identifying and evaluating reasons, conclusions, assumptions, analogies, concepts and principles), and their ability to use these skills in assessing other people’s arguments, making decisions and constructing their own reasoning to the kinds of ethical problems a scientist is likely to encounter;
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Students are able to identify and critically evaluate moral arguments, to analyse and to solve moral dilemmas considering different normative perspectives and to create their own well-justified reasoning for taking decisions to the kind of ethical problems a scientist is likely to encounter during the different phases of biomedical research.

Lectures

G. Achermann

I. Introduction to Moral Reasoning
1. Ethic - the basics
1.1 What ethics is not… 1.2 Recognising an ethical issue (awareness) 1.3 What is ethics? Personal, cultural and ethical values, principles and norms 1.4 Ethic: a classification
1.5 Research Ethics: what is it and why is it important?

2. Normative Ethics
2.1 What is normative ethics? 2.2 Types of normative theories – three different ways of thinking about ethics: Virtue theories, duty-based theories, consequentialist theories
2.3 The plurality of normative theories (moral pluralism); 2.4 Roles of normative theories in “Research Ethics”

3. Decision making: How to solve a moral dilemma
3.1 How (not) to approach ethical issues 3.2 What is a moral dilemma? Is there a correct method for answering moral questions? 3.3 Methods of making ethical decisions 3.4 Is there a “right” answer?

II. Research Ethics - Internal responsibilities
1. Integrity in research and research misconduct
1.1 What is research integrity and why is it important? 1.2 What is research misconduct? 1.3 Questionable/Detrimental Research Practice (QRD/DRP) 1.4 What is the incidence of misconduct? 1.5 What are the factors that lead to misconduct? 1.6 Responding to research wrongdoing 1.7 The process of dealing with misconduct 1.8 Approaches to misconduct prevention and for promoting integrity in research

2. Data Management
2.1 Data collection and recordkeeping 2.2 Analysis and selection of data 2.3 The (mis)representation of data 2.4 Ownership of data 2.5 Retention of data 2.6 Sharing of data (open research data) 2.7 The ethics of big data

3. Publication ethics / Responsible publishing
3.1 Background 3.2 Criteria for being an author 3.3 Ordering of authors 3.4 Publication practices

III. Research Ethics – External responsibilities
1. Research involving human subjects
1.1 History of research with human subjects 1.2 Basic ethical principles – The Belmont Report 1.3 Requirements to make clinical research ethical 1.4 Social value and scientific validity
1.5 Selection of study participants – the concept of vulnerability 1.6 Favourable risk-benefit ratio 1.7 Independent review - Ethics Committees 1.8 Informed consent 1.9 Respect for potential and enrolled participants

2. Social responsibility
2.1 What is social responsibility? a) Social responsibility of the individual scientist b) Social responsibility of the scientific community as a whole; 2.2 Participation in public discussions: a) Debate & Dialogue b) Communicating risks & uncertainties c) Science and the media
2.3 Public advocacy (policy making)

3. Dual use research
3.1 Introduction to Dual use research 3.2 Case study – Censuring science? 3.3 Transmission studies for avian flu (H5N1) 3.4 Synthetic biology

Lecture notes

Course material (handouts, case studies, exercises, surveys and papers) will be available during the lectures and on the course homepage.

Prerequisites / notice

What are the requirements?
First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).
### Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
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### Contract Design I

**Abstract**

This course is taught by Professor Alexander Stremitzer [https://laweconbusiness.ethz.ch/group/professor/stremitzer.html]. Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Contract Design I (851-0742-00L; Fall 2022)" and enroll. The password is "ContractDesign01".

**Objective**

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

**Lecture notes**

Handouts, prerecorded videos, slides, and other materials

**Prerequisites / notice**

Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

**Course Design I** is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, D-MATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

### Intellectual Property: Introduction

**Abstract**

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.
The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickness).

851-0738-01L The Role of Intellectual Property in the Engineering and Technical Sector

This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html). To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

Objective

Case studies will illustrate and deepen the topics addressed during the lecture.

Prerequisites / notice

The lecture addresses students in the fields of engineering, science and other related technical fields.

Fostered competencies

Subject-specific Competencies Method-specific Competencies

Concepts and Theories Problem-solving

assessed assessed

Personal Competencies

Critical Thinking Self-awareness and Self-reflection

assessed assessed

851-0742-01L Contract Design II

This course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).

Objective

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

Prerequisites / notice

851-0157-28L Life and Death

This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

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To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

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Research Ethics

**Objective**
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

**Content**
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarization with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

**Prerequisites**
Students with a strong background in machine learning and excellent programming skills (preferably in Python).

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**Literature**
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O'Neill et al., Environmental Values, 2008
- Konrad Ott/Jan Diers/ Lieske Voget-Kleschin, Handbuch Umweltethik, 2016

**General introductions:**
- Marcus Düwell et al. (Hrsg.), Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006
- Johann S. Ach et al. (Hrsg.), Grundkurs Ethik 1. Grundlagen, Paderborn (mentis) 2008

**Prerequisites / notice**
The procedure for accumulating CP will be explained at the start of term.
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

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**AI4Good**

**Objective**
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

**Content**
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning.

Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

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On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

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Lecture notes
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First and foremost your strong willingness to seriously achieve the main learning outcomes as indicated in the Course Catalogue (specific learning outcomes for each module will be provided at the beginning of the course). For successfully completing the course Research Ethics, the following commitment is absolutely necessary (but not sufficient) (observed success factors for many years!):
1. Your regular presence is absolutely required (so please no double, parallel enrollment for courses taking place at the identical time!) connected with your active participation during class, e.g. taking notes, contributing to discussions (in group as well as in plenary class), solving exercises.
2. Having the willingness and availability of the necessary time for regularly preparing the class (at least 1 hour per week, probably even more…).

Fostered competencies

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<td>Self-awareness and Self-reflection</td>
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851-0745-00L Ethics Workshop: The Impact of Digital Life on Society
W 2 credits 2S E. Vayena, A. Blasimme, A. Ferretti, C. Landers, J. Sleigh

Open to all Master level / PhD students.

Abstract
This workshop focuses on understanding and managing the ethical and social issues arising from the integration of new technologies in various aspects of daily life.
- Explain relevant concepts in ethics.
- Evaluate the ethical dimensions of new technology uses.
- Identify impacted stakeholders and who is ethically responsible.
- Engage constructively in the public discourse relating to new technology impacts.
- Review tools and resources currently available that facilitate resolutions and ethical practice.
- Work in a more ethically reflective way.
Content

The workshop offers students an experience that trains their ability for critical analysis and develops awareness of responsibilities as a researcher, consumer, and citizen. Learning will occur in the context of three intensive workshop days, which are highly interactive and focus on the development and application of reasoning skills.

The workshop will begin with some fundamentals: the nature of ethics, of consent and big data, of AI ethics, public trust and health ethics. Students will then be introduced to key ethical concepts such as fairness, autonomy, trust, accountability, justice, as well different ways of reasoning about the ethics of digital technologies.

A range of practical problems and issues in the domains of education, media, society, digital health and justice will be then considered. These domains are represented respectively by unique and interesting case studies. Each case study has been selected not only for its timely and engaging nature, but also for its relevance. Through the analysis of these case studies key ethical questions (such as fairness, accountability, explainability, access etc.) will be highlighted and questions of responsibility and tools for ethical practice will be explored.

Throughout, the emphasis will be on learning to make sound arguments about the ethical aspects of policy, practice and research.

Fostered competencies

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<tr>
<th>851-0157-28L</th>
<th>Life and Death</th>
<th>W</th>
<th>3 credits</th>
<th>2V</th>
<th>M. Hagner</th>
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</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.</td>
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<tr>
<td>Objective</td>
<td>There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.</td>
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<tr>
<td>Content</td>
<td>Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.</td>
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<tr>
<th>851-0426-00L</th>
<th>Paul Feyerabend’s Anarchistic Theory of Knowledge</th>
<th>W</th>
<th>3 credits</th>
<th>2S</th>
<th>M. Hagner, M. Hampe</th>
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<tbody>
<tr>
<td>Abstract</td>
<td>Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.</td>
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<tr>
<td>Objective</td>
<td>It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.</td>
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<td>Content</td>
<td>This course is designed to help students understand political, social, and cultural phenomena in particular historical settings.</td>
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<th>851-0011-00L</th>
<th>The Body in Global History</th>
<th>W</th>
<th>3 credits</th>
<th>2S</th>
<th>E. Valdameri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>While being the universal constant which is common to every human being in history, the body is also culturally and historically specific. In this seminar we will examine how ideas of the body have changed throughout history and how these ideas of the body can be useful to understand political, social, and cultural phenomena in particular historical settings.</td>
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<td>Objective</td>
<td>Students learn the history of the body from mid-eighteenth century onwards through examples taken from the multidisciplinary scholarship on the body with a special, albeit not exclusive, focus on colonial and postcolonial contexts. More specifically, students are sensitized to the historical and cultural varieties of the human body that challenge scientific understandings of it as an unchanging biological entity.</td>
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<td>Content</td>
<td>The course is structured thematically, adopts a multidisciplinary approach, and uses academic texts as well as concrete examples. It intends to a) enable STEM students to develop new perspectives on their core subjects by bringing them in dialogue with the themes dealt with and by raising ethical questions; b) familiarise students in general with major topics in the field of the recent scholarship on the body and make them mindful of the multiple ways in which understanding the body and its relationship with culture and power can help think critically of the present we live in.</td>
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<tr>
<th>851-0601-00L</th>
<th>Participatory Resilience</th>
<th>W</th>
<th>3 credits</th>
<th>3G</th>
<th>D. Helbing, J. Argota Sánchez-Vaquerizo, C. I. Hausladen, S. Mahajan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.</td>
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<tr>
<td>Objective</td>
<td>The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.</td>
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The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3-5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day. We encourage students from different backgrounds and expertise to participate in this course.

Please visit our website: https://participatoryresilience.ch/

Objective
This seminar introduces theory and methods in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the method as well as their procedure and results to the plenary. Active participation is vital for the success of the seminar, and students are expected to contribute to presenters of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

851-0252-01L
Human-Computer Interaction: Cognition and Usability
Number of participants limited to 35.

851-0742-00L
Contract Design I
Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Handouts, prerecorded videos, slides, and other materials

Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).
The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

**Content**

Vorgesehene Strukturierung der Vorlesung:

1. Welches Recht gilt im E-Business?
   - Internationalität des Internets
   - Reguliierte Branchen

2. Gestaltung und Vermarktung von E-Business-Angeboten
   - Verwendung fremder und Schutz der eigenen Inhalte
   - Haftung im E-Business (und wie sie beschränkt werden kann)
   - Domain-Namen

3. Beziehung zu E-Business-Kunden
   - Verträge im E-Business, Konsumentenschutz
   - Elektronische Signaturen
   - Datenschutz
   - Spam

4. Verträge mit E-Business-Providern

Änderungen, Umstellungen und Kürzungen bleiben vorbehalten. Der aktuelle Termin- und Themenplan ist zu gegebener Zeit über die elektronische Dokumentenablage abrufbar.

**Lecture notes**

Es wird mit Folien gearbeitet, die als PDF über die elektronische Dokumentenablage (ILIAS) auf dem System der ETHZ vorgängig abrufbar sind. Auf dem Termin- und Themenplan (ebenfalls online abrufbar) sind Links zu Gesetzestexten und weiteren Unterlagen abrufbar. Schliesslich wird jede Vorlesung auch als Podcast aufgezeichnet, der jedoch nur für die Studierenden mit einem Passwort (erhältlich beim Dozenten) zugänglich sind.

**Literature**

Weiterführende Materialien, Links und Literatur sind auf dem Termin- und Themenplan aufgeführt (zu gegebener Zeit abrufbar via elektronische Dokumentenablage).

**Prerequisites / notice**


**Fostered competencies**

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| Social Competencies          | Communication           | assessed |
|------------------------------|                        |          |
|                              | Cooperation and Teamwork| assessed |
|                              | Customer Orientation    | assessed |
|                              | Negotiation             | assessed |

| Personal Competencies        | Creative Thinking       | assessed |
|------------------------------|                        |          |

**851-0727-02L E-Business-Law**

**W** 2 credits 2V D. Rosenthal

**Objective**

The objective is knowing and understanding key legal concepts relevant for doing e-business, in particularly understanding how e-business is regulated by law nationally and internationally, how contracts are concluded and performed electronically, which rules have to be obeyed in particular in the Internet with regard to third party and own content and client data, the concept of liability applied in e-business and the role of the law in the practical implementation and operation of e-business applications.

**Content**

Vorgesehene Strukturierung der Vorlesung:

1. Welches Recht gilt im E-Business?
   - Internationalität des Internets
   - Reguliierte Branchen

2. Gestaltung und Vermarktung von E-Business-Angeboten
   - Verwendung fremder und Schutz der eigenen Inhalte
   - Haftung im E-Business (und wie sie beschränkt werden kann)
   - Domain-Namen

3. Beziehung zu E-Business-Kunden
   - Verträge im E-Business, Konsumentenschutz
   - Elektronische Signaturen
   - Datenschutz
   - Spam

4. Verträge mit E-Business-Providern

Änderungen, Umstellungen und Kürzungen bleiben vorbehalten. Der aktuelle Termin- und Themenplan ist zu gegebener Zeit über die elektronische Dokumentenablage abrufbar.

**Lecture notes**

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**Literature**

Weiterführende Materialien, Links und Literatur sind auf dem Termin- und Themenplan aufgeführt (zu gegebener Zeit abrufbar via elektronische Dokumentenablage).

**Prerequisites / notice**


**Fostered competencies**

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<td>Problem-solving</td>
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</table>

| Social Competencies          | Communication           | assessed |
|------------------------------|                        |          |
|                              | Cooperation and Teamwork| assessed |
|                              | Customer Orientation    | assessed |
|                              | Negotiation             | assessed |

| Personal Competencies        | Creative Thinking       | assessed |
|------------------------------|                        |          |

**851-0738-00L Intellectual Property: Introduction**

**W** 2 credits 2V M. Schweizer

**Objective**

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

**851-0252-13L Network Modeling**

**W** 3 credits 2V C. Stadtfeld, A. Espinosa Rada, A. Uzaheta Berdugo

Students are required to have basic knowledge in inferential statistics, such as regression models.
Abstract
Network Science is a distinct domain of data science that focuses on relational systems. Various models have been proposed to describe structures and dynamics of networks. Statistical and numerical methods have been developed to fit these models to empirical data. Emphasis is placed on the statistical analysis of (social) systems and their connection to social theories and data sources.

Objective
Students will be able to develop hypotheses that relate to the structures and dynamics of (social) networks, and test those by applying advanced statistical network methods such as exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs). Students will be able to explain and compare various network models, and understand how those can be fit to empirical data. This will enable students to independently address research questions from various social science fields.

Content
The following topics will be covered:

- Introduction to network models and their applications
  - Stylized models:
    * uniform random graph models
    * small world models
    * preferential attachment models
  - Models for testing hypotheses while controlling for the network structure:
    * Quadratic assignment procedure regression (QAP regression)
    - Models for testing hypotheses on the network structure:
      * Models for one single observation of a network: exponential random graph models (ERGMs)
      * Models for panel network data: stochastic actor-oriented models (SAOMs)

The application of these models is illustrated through examples and practical sessions involving the analysis of network data using the software R.

Lecture notes
Slides and lecture notes are distributed via the associated course moodle.

Literature

Prerequisites / notice
Students are required to have basic knowledge in inferential statistics and should be familiar with linear and logistic regression models.

851-0252-15L
Network Analysis
Particularly suitable for students of D-INFK, D-MATH
W 3 credits 2V U. Brandes

Objective
Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Content
The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

* Empirical Research and Network Data
* Macro and Micro Structure
* Centrality
* Roles
* Cohesion

Lecture notes
Lecture notes are distributed via the associated course moodle.

Literature

851-0732-06L
Law & Tech
Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/s/o7dtthKV5jA9CE) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

Objective
This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.
The planned course outline is below

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

851-0101-86L  Complex Social Systems: Modeling Agents, Learning, and Games  W  3 credits  2S  N. Antulov-Fantulin, D. Carpentras, D. Helbing

Number of participants limited to 100.

Prerequisites: Basic programming skills, elementary probability and statistics.

Abstract
This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

Objective
The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.

Content
Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lecture notes
The lecture slides will be presented on the course web page after each lecture.

Literature
Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/281629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

Prerequisites / notice
The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

Fostered competencies

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed
Media and Digital Technologies not assessed
Problem-solving assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation not assessed
Leadership and Responsibility assessed
Self-presentation and Social Influence assessed
Sensitivity to Diversity assessed
Negotiation not assessed

Personal Competencies
Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics assessed
Self-awareness and Self-reflection assessed
Self-direction and Self-management assessed

851-0760-00L  Building a Robot Judge: Data Science for Decision- W  3 credits  2V  E. Ash

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2377 of 2416
### Building a Robot Judge: Data Science for Decision-Making (Course Project)

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

Please register only if attending the lecture course or with consent of the instructor.

#### Prerequisites / notice

Some programming experience in Python is required, and some experience with text mining is highly recommended.

### From Traffic Modeling to Smart Cities and Digital Democracies

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience. Some programming experience in Python is required, and some experience with NLP is highly recommended.

To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Prerequisites / notice

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon’s central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

**Data:** 01.11.2022 12:41  
**Autumn Semester 2022**  
**Page 2380 of 2416**
This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

851-0727-02L E-Business-Law

Prerequisites / notice

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.

Literature

Reading materials and slides will be available via Moodle.

Lecture notes

Reading materials and slides will be available via Moodle.

851-0252-01L Human-Computer Interaction: Cognition and Usability

Number of participants limited to 35.

Prerequisites / notice

This seminar introduces theory and methods in human-computer interaction and usability. Cognitive Science provides a theoretical framework for designing user interfaces as well as a range of methods for assessing usability (user testing, cognitive walkthrough, GOMS). The seminar will provide an opportunity to experience some of the methods in applied group projects.
This seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the methodology as well as their procedure and results to the plenary.

Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

**Objective**

The seminar will introduce key topics, theories and methodology in human-computer interaction (HCI) and usability. Presentations will cover basics of human-computer interaction and selected topics like mobile interaction, adaptive systems, human error and attention. A focus of the seminar will be on getting to know evaluation techniques in HCI. Students form work groups that first familiarize themselves with a select usability evaluation method (e.g. user testing, GOMS, task analysis, heuristic evaluation, questionnaires or Cognitive Walkthrough). They will then apply the methods to a human-computer interaction setting (e.g. an existing software or hardware interface) and present the methodology as well as their procedure and results to the plenary.

Active participation is vital for the success of the seminar, and students are expected to contribute to presentations of foundational themes, methods and results of their chosen group project. In order to obtain course credit a written essay / report will be required (details to be specified in the introductory session of the course).

**851-0735-01L**  
**Law for Entrepreneurs**  
2 credits  
P. Peyrot  
Number of participants limited to 100  

- Particularly suitable for students of D-ITET, D-MAVT

**Abstract**

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Objective**

The students shall obtain the following competence:
- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

**Lecture notes**

A comprehensive script will be made available online on the moodle platform.

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**851-0738-01L**  
**The Role of Intellectual Property in the Engineering and Technical Sector**  
2 credits  
K. Houshang Pour Islam  
Number of participants limited to 100  

- Particularly suitable for students of D-BAUG, D-BIOL, D-BSEE, D-CHAB, D-ITET, D-MAVT

**Abstract**

The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

**Objective**

In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information. The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

**Topics covered during the lecture will include:**
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

**Case studies**

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

**Prerequisites / notice**

The lecture addresses students in the fields of engineering, science and other related technical fields.

The lecture addresses students in the fields of engineering, science and other related technical fields.

**851-0738-00L**  
**Intellectual Property: Introduction**  
2 credits  
M. Schweizer  
Number of participants limited to 100  

- Particularly suitable for students of D-CHAB, D-IFNK, D-ITET, D-MAVT, D-MATL, D-MTEC

**Abstract**

The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

**Objective**

The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thicket).

**851-0101-86L**  
**Complex Social Systems: Modeling Agents, Learning, and Games**  
3 credits  
N. Antulov-Fantulin, D. Carpentras, D. Helbing  
Number of participants limited to 100  

**Prerequisites:** Basic programming skills, elementary probability and statistics.

**Abstract**

This course introduces mathematical and computational models to study techno-socio-economic systems and the process of scientific research. Students develop a significant project to tackle techno-socio-economic challenges in application domains of complex systems. They are expected to implement a model and communicating their results through a seminar thesis and a short oral presentation.

**Objective**

The students are expected to know a programming language and environment (Python, Java or Matlab) as a tool to solve various scientific problems. The use of a high-level programming environment makes it possible to quickly find numerical solutions to a wide range of scientific problems. Students will learn to take advantage of a rich set of tools to present their results numerically and graphically.

The students should be able to implement simulation models and document their skills through a seminar thesis and finally give a short oral presentation.
Students are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models.

Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

The lecture slides will be presented on the course web page after each lecture.

Agent-Based Modeling
https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2

Social Self-Organization

Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/261629187

Pedestrian, Crowd, and Evacuation Dynamics
https://www.research-collection.ethz.ch/handle/20.500.11850/45424

The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread)
https://science.sciencemag.org/content/342/6164/1337

The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.

Good programming skills and a good understanding of probability & statistics and calculus are expected.

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.

**Content**

**Lecture notes**

**Literature**

**Prerequisites / notice**

**Fostered competencies**

**Subject-specific Competencies**
- Concepts and Theories: assessed
- Techniques and Technologies: assessed

**Method-specific Competencies**
- Analytical Competencies: assessed
- Decision-making: assessed

**Social Competencies**
- Communication: assessed
- Cooperation and Teamwork: assessed

**Personal Competencies**
- Adaptability and Flexibility: assessed
- Creative Thinking: assessed

**Abstract**

This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

**Objective**

This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

**Content**

**Building a Robot Judge: Data Science for Decision-Making**

Particularly suitable for students of D-INFK, D-ITET, D-MTEC

**Building a Robot Judge: Data Science for Decision-Making (Course Project)**

This is the optional course project for "Building a Robot Judge: Data Science for the Law."

851-0760-00L

Building a Robot Judge: Data Science for Decision-Making

W 3 credits 2V E. Ash

851-0761-00L

Building a Robot Judge: Data Science for Decision-Making (Course Project)

W 2 credits 2V E. Ash

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2383 of 2416
Please register only if attending the lecture course or with consent of the instructor.

Some programming experience in Python is required, and some experience with text mining is highly recommended.

Abstract
Students investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models. This is the extra credit for a larger course project for the course.

Objective
In a semester paper, students (individually or in groups) will conceive and implement their own research project applying natural language tools to legal texts. Some programming experience in Python is required, and some experience with NLP is highly recommended.

Content
Students will investigate and implement the relevant machine learning tools for making legal predictions, including regression, classification, and deep neural networks models.

We will use these predictions to better understand the operation of the legal system. In a semester project, student groups will conceive and implement a research design for examining this type of empirical research question.

851-0650-00L
AI4Good a

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students’ initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0467-00L
From Traffic Modeling to Smart Cities and Digital Democracies

Number of participants limited to 40.

Abstract
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will reflect on the question of how democracy could be digitally upgraded to promote innovation, sustainability, and resilience.

Objective
To collect credit points, students will have to give a 30-40 minute presentation in the seminar, after which the presentation will be discussed. The presentation will be graded.

Content
This seminar will present speakers who discuss the challenges and opportunities arising for our cities and societies with the digital revolution. Besides discussing questions of automation using Big Data, AI and other digital technologies, we will also reflect on the question of how democracy could be digitally upgraded, and how citizen participation could contribute to innovation, sustainability, resilience, and quality of life. This includes questions around collective intelligence and digital platforms that support creativity, engagement, coordination and cooperation.
Literature

Martin Treiber and Arne Kesting
Traffic Flow Dynamics: Data, Models and Simulation

Dirk Helbing
Traffic and related self-driven many-particle systems
Reviews of Modern Physics 73, 1067
https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.73.1067

Dirk Helbing
An Analytical Theory of Traffic Flow (collection of papers)
https://www.researchgate.net/publication/281629187

Michael Batty, Kay Axhausen et al.
Smart cities of the future

Books by Michael Batty
https://link.springer.com/article/10.1140/epjst/e2012-01703-3

How social influence can undermine the wisdom of crowd effect
https://www.pnas.org/content/108/22/2020

Evidence for a collective intelligence factor in the performance of human groups
https://science.sciencemag.org/content/330/6004/686.full

Optimal incentives for collective intelligence
https://www.pnas.org/content/114/20/5077.short

Collective Intelligence: Creating a Prosperous World at Peace
https://www.amazon.com/Collective-Intelligence-Creating-Prosperous-World/dp/097156616X/

Big Mind: How Collective Intelligence Can Change Our World
https://www.amazon.com/Big-Mind-Collective-Intelligence-Change/dp/0691170797/

Programming Collective Intelligence
https://www.amazon.com/Programming-Collective-Intelligence-Building-Applications/dp/0596529325/

Urban architecture as connective-collective intelligence. Which spaces of interaction?
https://www.mdpi.com/2071-1050/5/7/2928

Build digital democracy
https://www.nature.com/news/society-build-digital-democracy-1.18690

How to make democracy work in the digital age
http://www.huffingtonpost.com/entry/how-to-make-democracy-work-in-the-digital-age_us_57a2f488e4b0456cb7e17e0f

Digital Democracy: How to make it work?
http://futurict.blogspot.com/2020/06/digital-democracy-how-to-make-it-work.html

Proof of witness presence: Blockchain consensus for augmented democracy in smart cities

Iterative Learning Control for Multi-agent Systems Coordination
https://www.amazon.co.uk/Iterative-Learning-Control-Multi-agent-Coordination-ebook/dp/B06XJVQC41/ref=sr_1_1?dchild=1&keywords=coordination+jennings+multi-agent&qid=1601973480&sr=8-1-fkmr1

Decentralized Collective Learning for Self-managed Sharing Economies
https://dl.acm.org/doi/abs/10.1145/3277668

Further literature will be recommended in the lectures.

Prerequisites / notice

Students need to present a new subject, for which they have not earned any credit points before.

Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Chatham House rules apply to this course. Materials may not be shared without previous written permission.
### Participatory Resilience

**Course Code:** 851-0426-00L  
**Course Title:** The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.  

**Objective:**  
By the end of the course, students will have the ability to:  
- Present, evaluate, and analyze potential solutions for urban resilience problems using open-source digital tools and participatory methods.  
- Present, evaluate, and analyze opportunities to understand what role participatory approaches can play in making cities more resilient.  
- Use open-source hardware/software and the Internet of Things to solve specific problems related to urban resilience.  
- Gain practical experience in working in teams and contribute to an interdisciplinary hackathon.  

**Content:**  
- **Method-specific Competencies:**  
  - Decision-making  
  - Media and Digital Technologies  
  - Problem-solving  
  - Project Management  
- **Social Competencies:**  
  - Communication  
  - Cooperation and Teamwork  
  - Customer Orientation  
  - Leadership and Responsibility  
  - Self-presentation and Social Influence  
  - Sensitivity to Diversity  
  - Negotiation  
- **Personal Competencies:**  
  - Adaptability and Flexibility  
  - Creative Thinking  
  - Critical Thinking  
  - Integrity and Work Ethics  
  - Self-awareness and Self-reflection  
  - Self-direction and Self-management  

**Prerequisites:**  
- It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.  

**Assessment:**  
- The course will be assessed during the hackathon through the completion of the hackathon prototype and presentation of findings.  
- Students will be required to engage in active participation and contribute to the team's project.  

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### Introduction to Cognitive Science

**Course Code:** 851-0252-02L  
**Course Title:** It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.  

**Objective:**  
- To present an overview of the foundations of cognitive science and investigate processes of human cognition, especially with respect to knowledge acquisition, knowledge representation and usage in information processing tasks.  

**Content:**  
- **Method-specific Competencies:**  
  - Decision-making  
  - Media and Digital Technologies  
  - Problem-solving  
  - Project Management  
- **Social Competencies:**  
  - Communication  
  - Cooperation and Teamwork  
  - Customer Orientation  
  - Leadership and Responsibility  
  - Self-presentation and Social Influence  
  - Sensitivity to Diversity  
  - Negotiation  
- **Personal Competencies:**  
  - Adaptability and Flexibility  
  - Creative Thinking  
  - Critical Thinking  
  - Integrity and Work Ethics  
  - Self-awareness and Self-reflection  
  - Self-direction and Self-management  

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### Participatory Resilience

**Course Code:** 851-0601-00L  
**Course Title:** The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.  

**Objective:**  
- To promote participatory resilience.  
- To focus on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.  

**Content:**  
- **Method-specific Competencies:**  
  - Decision-making  
  - Media and Digital Technologies  
  - Problem-solving  
  - Project Management  
- **Social Competencies:**  
  - Communication  
  - Cooperation and Teamwork  
  - Customer Orientation  
  - Leadership and Responsibility  
  - Self-presentation and Social Influence  
  - Sensitivity to Diversity  
  - Negotiation  
- **Personal Competencies:**  
  - Adaptability and Flexibility  
  - Creative Thinking  
  - Critical Thinking  
  - Integrity and Work Ethics  
  - Self-awareness and Self-reflection  
  - Self-direction and Self-management  

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### Law & Tech

**Course Code:** 851-0732-00L  
**Course Title:** The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.  

**Objective:**  
- To present an overview of the foundations of cognitive science and investigate processes of human cognition, especially with respect to knowledge acquisition, knowledge representation and usage in information processing tasks.  

**Content:**  
- **Method-specific Competencies:**  
  - Decision-making  
  - Media and Digital Technologies  
  - Problem-solving  
  - Project Management  
- **Social Competencies:**  
  - Communication  
  - Cooperation and Teamwork  
  - Customer Orientation  
  - Leadership and Responsibility  
  - Self-presentation and Social Influence  
  - Sensitivity to Diversity  
  - Negotiation  
- **Personal Competencies:**  
  - Adaptability and Flexibility  
  - Creative Thinking  
  - Critical Thinking  
  - Integrity and Work Ethics  
  - Self-awareness and Self-reflection  
  - Self-direction and Self-management  

**Assessment:**  
- The course will be assessed through the completion of the hackathon prototype and presentation of findings.  
- Students will be required to engage in active participation and contribute to the team's project.  

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### Introduction to Cognitive Science

**Course Code:** 851-0601-00L  
**Course Title:** Does not take place this semester.  

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### Law & Tech

**Course Code:** 851-0732-00L  
**Course Title:** The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.
The planned course outline is below:

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

### D-MATH

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
</tr>
</thead>
<tbody>
<tr>
<td>851-0742-00L</td>
<td>Contract Design I</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>A. Stremitzer</td>
</tr>
</tbody>
</table>

This course is taught by Professor Alexander Stremitzer ([https://laweconbusiness.ethz.ch/group/professor/stremitzer.html](https://laweconbusiness.ethz.ch/group/professor/stremitzer.html)). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for “Contract Design I (851-0742-00L; Fall 2022)” and enroll. The password is “ContractDesign01”.

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

**Contract Design I** aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tails the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Handouts, prerecorded videos, slides, and other materials are available on Moodle.

**Contract Design I** is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke ([lucas.gericke@gess.ethz.ch](mailto:lucas.gericke@gess.ethz.ch)) or Serge von Steiger ([serge.vonsteiger@gess.ethz.ch](mailto:serge.vonsteiger@gess.ethz.ch)).

**Fostered competencies**

- **Subject-specific Competencies**
  - Concepts and Theories: assessed
  - Techniques and Technologies: assessed

- **Method-specific Competencies**
  - Analytical Competencies: assessed
  - Decision-making: assessed
  - Problem-solving: assessed

- **Social Competencies**
  - Communication: assessed
  - Cooperation and Teamwork: assessed
  - Customer Orientation: assessed
  - Negotiation: assessed

- **Personal Competencies**
  - Creative Thinking: assessed

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<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
<th>Lecturers</th>
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<tbody>
<tr>
<td>851-0252-15L</td>
<td>Network Analysis</td>
<td>W</td>
<td>3</td>
<td>2V</td>
<td>U. Brandes</td>
</tr>
</tbody>
</table>

Particularly suitable for students of D-INFK, D-MATH

Network science is a distinct domain of data science that is characterized by a specific kind of data being studied. While areas of application range from archaeology to zoology, we concern ourselves with social networks for the most part. Emphasis is placed on descriptive and analytic approaches rather than theorizing, modeling, or data collection.

Data: 01.11.2022 12:41  Autumn Semester 2022  Page 2387 of 2416
Objective
Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

Content
The following topics will be covered with an emphasis on structural and computational approaches and frequent reference to their suitability with respect to substantive theory:

* Empirical Research and Network Data
* Macro and Micro Structure
* Centrality
* Roles
* Cohesion

Lecture notes
Lecture notes are distributed via the associated course moodle.

Literature

853-0061-00L
Introduction to Cybersecurity Politics

Abstract
The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures). Students will be able to identify and categorize research problems that call for network approaches while appreciating differences across application domains and contexts. They will master a suite of mathematical and computational tools, and know how to design or adapt suitable methods for analysis. In particular, they will be able to evaluate such methods in terms of appropriateness and efficiency.

Objective
Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.

Content
We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

Lecture notes
A script with background information and comments on the literature will be made available at the beginning of the semester.

Literature
Lecture notes are distributed via the associated course moodle.

Prerequisites / notice
The lecture is being supported by a website on Moodle.

Fostered competencies

<table>
<thead>
<tr>
<th>Subject-specific Competencies</th>
<th>W</th>
<th>3 credits</th>
<th>2G</th>
<th>M. Dunn Caveltiy, F. J. Egloff</th>
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<tr>
<td>Concepts and Theories</td>
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<td>Analytical Competencies</td>
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<td>assessed</td>
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<tr>
<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Problem-solving</td>
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<td>Communication</td>
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<td>Cooperation and Teamwork</td>
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<td>Sensitivity to Diversity</td>
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<td>Critical Thinking</td>
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<td>Self-direction and Self-management</td>
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853-8002-00L
The Role of Technology in National and International Security Policy

Abstract
The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

Objective
Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

Content

Literature
Literatur für die einzelnen Sitzungen wird auf Moodle bereitgestellt.

Prerequisites / notice
The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos, oliver.roos@sipo.gess.ethz.ch.

851-0650-00L
AI4Good

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members. Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.
The course aims are:

The course focuses on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of the scientific institutions.

The goal is to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, and suggest a pluralist integration.

The course analyses the evolution of the relation between science and philosophy during the Middle Age and the Early Modern Period.

There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II.

To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

The course focuses on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially astronomy, astrology, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.

This course will follow Michele Friend's book "pluralism in mathematics". It will survey various mainstream philosophies of mathematics, and suggest a pluralist approach.

The course aims will be to introduce students to mainstream philosophies of mathematics, allow them to critically examine common views about mathematics, develop their analytic skills by handling philosophical questions, and enable a pluralist approach to philosophical questions.

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<th>Number</th>
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<td>851-0703-00L</td>
<td>Introduction to Law</td>
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<td>2V</td>
<td>O. Streiff Gnöpff</td>
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<td></td>
<td>Particularly suitable for students of D-ARCH, D-MAVT, D-MATL</td>
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<tr>
<td>Abstract</td>
<td>This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, private law and the law of the EU are covered.</td>
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<tr>
<td>Objective</td>
<td>Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.</td>
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<td>Content</td>
<td>Basic concepts of law, sources of law.</td>
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<td></td>
<td>Private law: Contract law (particularly contract for work and services), tort law, property law.</td>
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<td>Public law: Human rights, administrative law, procurement law, procedural law.</td>
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<td>Insights into the law of the EU and into criminal law.</td>
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<tr>
<td>Lecture notes</td>
<td>Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)</td>
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<td>Literature</td>
<td>Further documents will be available online (see <a href="https://moodle-app2.let.ethz.ch/course/view.php?id=17512">https://moodle-app2.let.ethz.ch/course/view.php?id=17512</a>).</td>
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<td>Intellectual Property: Introduction</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>M. Schweizer</td>
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<td>Particularly suitable for students of D-CHEM, D-CHB, D-INFK, D-ITET, D-MAVT, D-MATL, D-MTEC</td>
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<tr>
<td>Abstract</td>
<td>The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.</td>
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<td>Objective</td>
<td>The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.</td>
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<td>Content</td>
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<td>Decision-making</td>
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<td>Media and Digital Technologies</td>
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<td>Cooperation and Teamwork</td>
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<td>Customer Orientation</td>
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<td>Leadership and Responsibility</td>
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<td>Negotiation</td>
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<td>853-0047-01L</td>
<td>World Politics Since 1945: The History of International Relations (Without Exercises)</td>
<td>W</td>
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<td>A. Wenger</td>
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<tr>
<td>Abstract</td>
<td>This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.</td>
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<td>Objective</td>
<td>By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.</td>
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<td>Self-direction and Self-management</td>
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<td>701-0703-00L</td>
<td>Environmental Ethics</td>
<td>W</td>
<td>2</td>
<td>2V</td>
<td>A. Deplazes Zemp</td>
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<tr>
<td>Abstract</td>
<td>The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.</td>
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<tr>
<td>Objective</td>
<td>Students who have attended or will attend the lecture &quot;Introduction to Law for Civil Engineering&quot; (851-0703-03L) or &quot;Introduction to Law&quot; (851-0708-00L), cannot register for this course unit.</td>
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<td>Content</td>
<td>Particularly suitable for students of D-ARCH, D-MAVT, D-MATL</td>
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<tr>
<td></td>
<td>Self-direction and Self-management</td>
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853-0061-00L Introduction to Cybersecurity Politics W 3 credits 2G M. Dunn Caveltty, F. J. Egloff

Abstract
The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats and different answers to these new challenges (countermeasures).

Objective
Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges for and the motivations of states to be active in cyberspace offensively and defensively and they are familiar with the consequences for international politics.

Content
We start with an overview of cybersecurity issues from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

Lecture notes
A script with background information and comments on the literature will be made available at the beginning of the semester.

Literature
Literature for each session will be available on Moodle.

Prerequisites / notice
The lecture is being supported by a website on Moodle.

853-8002-00L The Role of Technology in National and International Security Policy W 3 credits 2G O. Thränert, A. Dossi, S.-C. Fischer, M. Leese, N. Masuhr

Abstract
The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

Objective
Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

Content

Literature
Literatur für die einzelnen Sitzungen wird auf Moodle bereitgestellt.

Prerequisites / notice
The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos, oliver.roos@alpo.gess.ethz.ch.

851-0650-00L AI4Good W 3 credits 2G J. D. Wegner

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning.

Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students' initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python).

851-0426-00L Paul Feyerabend's Anarchistic Theory of Knowledge W 3 credits 2S M. Hagner, M. Hampe

Prerequisites / notice
The procedure for accumulating CP will be contributed at the start of term.

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.
Abstract
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Objective
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

Content
We will start this seminar with a close reading of Paul Feyerabends Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

**D-MTEC**

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<tr>
<th>Number</th>
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<td>851-0252-10L</td>
<td>Project in Behavioural Finance</td>
<td>W</td>
<td>3</td>
<td>2S</td>
<td>S. Andraszewicz, C. Hölscher, A. C. Roberts</td>
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<td>851-0738-00L</td>
<td>Intellectual Property: Introduction</td>
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<td><em>Particularly suitable for students of D-MTEC</em></td>
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<tr>
<td>363-0565-00L</td>
<td>Principles of Macroeconomics</td>
<td>W</td>
<td>3</td>
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<td>J.-E. Sturm</td>
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**Autumn Semester 2022**

This course examines the behaviour of macroeconomic variables, such as gross domestic product, unemployment and inflation rates. It tries to answer questions like: How can we explain fluctuations of national economic activity? What can economic policy do against unemployment and inflation?

**Objective**
This lecture will introduce the fundamentals of macroeconomic theory and explain their relevance to every-day economic problems.

**Content**
This helps you understand the world in which you live. There are many questions about the macroeconomy that might spark your curiosity. Why are living standards so meagre in many African countries? Why do some countries have high rates of inflation while others have stable prices? Why have some European countries adopted a common currency? These are just a few of the questions that this course will help you answer.

Furthermore, this course will give you a better understanding of the potential and limits of economic policy. As a voter, you help choose the policies that guide the allocation of society's resources. When deciding which policies to support, you may find yourself asking various questions about economics. What are the burdens associated with alternative forms of taxation? What are the effects of free trade with other countries? How does the government budget deficit affect the economy? These and similar questions are always on the minds of policy makers.

**Lecture notes**
The course webpage (to be found at https://moodle-app2.let.ethz.ch/course/view.php?id=17628) contains announcements, course information and lecture slides.

**Literature**

This book can also be used for the course '363-0503-00L Principles of Microeconomics' (Filippini).

Besides this textbook, the slides, lecture notes and problem sets will cover the content of the lecture and the exam questions.
Fostered competencies

Subject-specific Competencies
- Concepts and Theories: assessed
- Techniques and Technologies: not assessed

Method-specific Competencies
- Analytical Competencies: assessed
- Decision-making: not assessed
- Media and Digital Technologies: not assessed
- Problem-solving: assessed
- Project Management: not assessed

Social Competencies
- Communication: not assessed
- Cooperation and Teamwork: not assessed
- Customer Orientation: not assessed
- Leadership and Responsibility: not assessed
- Self-presentation and Social Influence: assessed
- Sensitivity to Diversity: not assessed
- Negotiation: not assessed

Personal Competencies
- Adaptability and Flexibility: not assessed
- Creative Thinking: not assessed
- Critical Thinking: assessed
- Integrity and Work Ethics: not assessed
- Self-awareness and Self-reflection: not assessed
- Self-direction and Self-management: not assessed

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363-0503-00L  Principles of Microeconomics

W  3 credits  2G  M. Filippini

Abstract
The course introduces basic principles, problems and approaches of microeconomics. This provides the students with reflective and contextual knowledge on how societies use scarce resources to produce goods and services and ensure a (fair) distribution.

Objective
The learning objectives of the course are:

1. Students must be able to discuss basic principles, problems and approaches in microeconomics.
2. Students can analyse and explain simple economic principles in a market using supply and demand graphs.
3. Students can contrast different market structures and describe firm and consumer behaviour.
4. Students can identify market failures such as externalities related to market activities and illustrate how these affect the economy as a whole.
5. Students can also recognize behavioural failures within a market and discuss basic concepts related to behavioural economics.
6. Students can apply simple mathematical concepts on economic problems.

Content
The resources on our planet are finite. The discipline of microeconomics therefore deals with the question of how society can use scarce resources to produce goods and services and ensure a (fair) distribution. In particular, microeconomics deals with the behaviour of consumers and firms in different market forms. Economic considerations and discussions are not part of classical engineering and science study programme. Thus, the goal of the lecture "Principles of Microeconomics" is to teach students how economic thinking and argumentation works. The course should help the students to look at the contents of their own studies from a different perspective and to be able to critically reflect on economic problems discussed in the society.

Topics covered by the course are:
- Supply and demand
- Consumer demand: neoclassical and behavioural perspective
- Cost of production: neoclassical and behavioural perspective
- Welfare economics, deadweight losses
- Governmental policies
- Market failures, common resources and public goods
- Public sector, tax system
- Market forms (competitive, monopolistic, monopolistic competitive, oligopolistic)
- International trade

Lecture notes
Lecture notes, exercises and reference material can be downloaded from Moodle.

Literature
The book can also be used for the course 'Principles of Macroeconomics' (Sturm)

For students taking only the course 'Principles of Microeconomics' there is a shorter version of the same book:

Complementary:

Prerequisites / notice
GESS (Science in Perspective): This lecture is for MSc students only. BSc students register for 363-1109-00L Einführung in die Mikroökonomie.
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351-1109-00L **Introduction to Microeconomics**

*GESS (Science in Perspective):*

This course is only for students enrolled in a Bachelor’s degree programme.

Students enrolled in a Master’s degree programme may attend “Principles of Microeconomics” (LE 363-0503-00L) instead.

Note for D-MAVT students: If you have already successfully completed “Principles of Microeconomics” (LE 363-0503-00L), then you will not be permitted to attend it again.

**Abstract**

The course introduces basic principles, problems and approaches of microeconomics. It describes economic decisions of households and firms, and their coordination through perfectly competitive markets.

**Objective**

Students acquire a deeper understanding of basic microeconomic models.

They acquire the ability to apply these models in the interpretation of real world economic contexts.

**Content**

Market, budget constraint, preferences, utility function, utility maximisation, demand, technology, profit function, cost minimisation, cost functions, perfect competition, information and communication technologies

**Lecture notes**

Course material in e-learning environment https://moodle-app2.let.ethz.ch/auth/shibboleth/login.php

**Literature**


**Prerequisites / notice**

This course “Einführung in die Mikroökonomie” (363-1109-00L) is intended for Bachelor students and LE 363-0503-00 "Principles of Microeconomics” for Master students.

851-0742-00L **Contract Design I**

This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.
Building a Robot Judge: Data Science for Decision-Making

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.

Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Handouts, prerecorded videos, slides, and other materials are mandatory. You are only allowed to miss two lectures absent special reasons.

Please register only if attending the lecture course or with consent of the instructor.

This is the optional course project for "Building a Robot Judge: Data Science for the Law."

Some programming experience in Python is required, and some experience with text mining is highly recommended.

Prerequisites / notice
Contract Design I is available to ETH students through the Science in Perspective (SiP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Contract Design I (851-0742-00L; Fall 2022)" and enroll. The password is "ContractDesign01".

Number of participants limited to 160.
Max 80 ETHZ and 80 UZH Students

E. Ash

851-0760-00L Building a Robot Judge: Data Science for Decision-Making

Particularly suitable for students of D-INFK, D-ITET, D-MTEC

W 3 credits 2V E. Ash

Abstract
This course explores the automation of decisions in the legal system. We delve into the machine learning tools needed to predict judge decision-making and ask whether techniques in model explanation and algorithmic fairness are sufficient to address the potential risks.

Objective
This course introduces students to the data science tools that may provide the first building blocks for a robot judge. While building a working robot judge might be far off in the future, some of the building blocks are already here, and we will put them to work.

Content
Data science technologies have the potential to improve legal decisions by making them more efficient and consistent. On the other hand, there are serious risks that automated systems could replicate or amplify existing legal biases and rigidities. Given the stakes, these technologies force us to think carefully about notions of fairness and justice and how they should be applied.

The focus is on legal prediction problems. Given the evidence and briefs in this case, how will a judge probably decide? How likely is a criminal defendant to commit another crime? How much additional revenue will this new tax law collect? Students will investigate and implement the relevant machine learning tools for making these types of predictions, including regression, classification, and deep neural networks models.

We then use these predictions to better understand the operation of the legal system. Under what conditions do judges tend to make errors? Against which types of defendants do parole boards exhibit bias? Which jurisdictions have the most tax loopholes? Students will be introduced to emerging applied research in this vein. In a semester paper, students (individually or in groups) will conceive and implement an applied data-science research project.

851-0761-00L Building a Robot Judge: Data Science for Decision-Making (Course Project)

This is the optional course project for "Building a Robot Judge: Data Science for the Law."

Please register only if attending the lecture course or with consent of the instructor.

Some programming experience in Python is required, and some experience with text mining is highly recommended.
851-0560-00L

**Al4Good**

- **Abstract**: The Al4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

- **Content**: The Al4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the code, the paper, and active participation in class.

- **Prerequisites / notice**: Students with a strong background in machine learning and excellent programming skills (preferably in Python).

851-0742-01L

**Contract Design II**

- **Abstract**: Contract Design II is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

- **Objective**: There is a possibility that representatives from companies that were previously engaged in similar deals will visit us in class and tell you about their experience firsthand. In Contract Design I, you will receive more detailed information on the content and learning objectives of Contract Design II. If you have urgent questions, please do not hesitate to send an e-mail to Professor Stremitzer’s Teaching Assistant Diego Caldera (diegoalberto.calderaherrera@uzh.ch).

- **Prerequisites / notice**: To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

851-0426-00L

**Paul Feyerabend's Anarchistic Theory of Knowledge**

- **Abstract**: Paul K. Feyeraberd characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyeraberd’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

- **Objective**: It is the aim of this seminar to become acquainted with the epistemology of Paul Feyeraberd and to analyze its relevance for our time. We will start this seminar with a close reading of Paul Feyeraberd’s Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabends-wider-den-methodenzwang-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyeraberd’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

851-0093-00L

**Ethical Issues in the Economy**

- **Abstract**: Ecological crises and growing social inequalities rise the urgent question: Is the global way we are doing economics reasonable? – Which kind of wealth is illegitimate? Is a policy of de-growth needed for protecting our ecological niche? Will technological devices like AI- driven market designs for public goods be the solution or is a change of attitudes necessary to cope with such problems?

- **Objective**: Participants should learn to know and being enabled to evaluate answers to the following questions: 1. To which extent are economic success and wealth something deserved, and to which extent are they the outcome of lucky circumstances or favorable conditions? What follows from the answer for the judgment on social inequalities? 2. How much consumption and growth are enough? 3. Which commons should not be privatized? 4. What should entrepreneurs and consumers be responsible for? 5. Does a sharing economy promote a responsible way of doing business? 6. Are technologies for regulating production and allocation of resources as well as regulating consumptions of goods apt to cope with problems of social inequality, of protecting our ecological niche, and do they empower producers, investors and consumers to act responsible? 7. What are the good things and what are the bad things about the global capitalist scheme doing business in the 21st century? 8. Do we need a de-globalization of doing economics?

851-0601-00L

**Participatory Resilience**

- **Abstract**: The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.
Objective

The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

Content

The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

Please visit our website: https://participatoryresilience.ch/

Prerequisites / notice

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.

851-0732-06L Law & Tech

Any students enrolling in the course must complete a short writing assignment (https://polybox.ethz.ch/index.php/%o7dtlHV/Sy%8CE) within two weeks of registering. Please contact the instructors via email (lawtech@gess.ethz.ch) for information about the assignment and for access to the course Slack workspace.

Abstract

This course introduces students to scientific and technological developments that require regulation or enable legal innovation. We focus particularly on the challenges to current law posed by prominent near-future technologies.

Objective

The course is intended for a wide range of engineering students as well as for law students interested in acquiring a better understanding of state-of-the-art technology. The course will combine both an overview of major areas of law that are relevant for the regulation of technology and guest lectures on new technological developments.

The course is open to ETH students through the Science in Perspective program of the Department of Humanities, Social and Political Sciences.

Content

The planned course outline is below

1. Overview of law and technology
2. Digital Platforms
3. AI Fairness
4. Consumer Bots and Consumer Protection
5. Drones
6. Integrated Case Studies on Topical Issues (e.g. social media platforms, drones, direct-to-consumer genetic testing)
7. Law and Tech scholarship series

D-MAVT

Contract Design I

This course is taught by Professor Alexander Stremitzer (https://laweconbusiness.ethz.ch/group/professor/stremitzer.html). Using practical examples, you will learn the connections between economic contract theory, contract law, and contract drafting. Further, you will apply this knowledge to practical cases to analyze contracts, recognize contractual problems, and develop suitable solutions.

It is NOT a legal drafting class focused on contractual language.

You can find all course materials and the most recent announcements on Moodle. Please log in to Moodle using your ETH or UZH credentials. Then search for "Contract Design I (851-0742-00L; Fall 2022)" and enroll. The password is "ContractDesign01".

Number of participants limited to 160.

Max 80 ETHZ and 80 UZH Students

Abstract

Contract Design I aims to bridge the gap between economic contract theory, contract law, and the writing of real-world contracts. In this course, we take a systematic approach to contract design. This means we first analyze the economic environment in which a transaction takes place, and then engineer contracts that achieve the desired outcome.
Objective
Contracts are agreements between parties to engage in transactions. A good contract creates value by giving parties the right incentives to meet their objectives. A good contract designer scrutinizes the economic situation in which parties find themselves and tailors the contract to the challenges at hand. To help you become sophisticated contract designers, we draw from insights for which more than half a dozen Nobel Prizes were awarded in the past two decades and transfer them to the art of writing real-world contracts. In other words, Integrative Course Contract Design will provide you with analytical tools related to contracting that are invaluable to successful lawyers, business leaders, and startup founders.

We will cover topics such as moral hazard, adverse selection, elicitation mechanisms, relationship-specific investments, and relational contracting and apply the theoretical insights to real-life case studies ranging from purchases & sales of assets, oil & gas exploration, movie production & distribution, construction & development, M&A deals, to executive compensation and many other types of transactions.

The course will be held in a flipped class-room model: This means that you will watch learning videos specifically produced for this course ahead of the lecture and we will use the class time to discuss real-world case studies.

ETH students: Your grade will consist of two parts:
1) You are required to take weekly computer-based quizzes during class time. Thus, it is imperative that you attend the lectures to be able to finish the quizzes and pass this course.
2) You have to compose short responses to take-home questions on the case studies we discussed in class and upload them.

Lecture notes
Note that UZH and HSG students enrolling in this course earn more ECTS on completing this course than ETH students. This is because UZH and HSG students must hand in an extensive group project in addition to the weekly quizzes and take-home questions.

Prerequisites / notice
Handouts, prerecorded videos, slides, and other materials

Attendance is mandatory. You are only allowed to miss two lectures absent special reasons.

Contract Design I is available to ETH students through the Science in Perspective (SIP) Program of D-GESS. This course is particularly suitable for students of D-ARCH, D-BAUG, D-CHAB, DMATH, D-MTEC, D-INFK, and D-MAVT. If you have any questions regarding the course, please write an email to the teaching assistants, Lucas Gericke (lucas.gericke@gess.ethz.ch) or Serge von Steiger (serge.vonsteiger@gess.ethz.ch).

Subject-specific Competencies
Concepts and Theories assessed
Techniques and Technologies assessed

Method-specific Competencies
Analytical Competencies assessed
Decision-making assessed

Social Competencies
Communication assessed
Cooperation and Teamwork assessed
Customer Orientation assessed
Negotiation assessed

Personal Competencies
Creative Thinking assessed

851-0738-01L
The Role of Intellectual Property in the Engineering and Technical Sector

Abstract
The lecture gives an overview of the fundamental aspects of intellectual property, which plays an important role in the daily routine of engineers and scientists. The lecture aims to make participants aware of the various methods of protection and to put them in a position to use this knowledge in the workplace.

Objective
In recent years, knowledge about intellectual property has become increasingly important for engineers and scientists. Both in production and distribution and in research and development, they are increasingly being confronted with questions concerning the patenting of technical inventions and the use of patent information.

The lecture will acquaint participants with practical aspects of intellectual property and enable them to use the acquired knowledge in their future professional life.

Topics covered during the lecture will include:
- The importance of innovation in industrialised countries
- An overview of the different forms of intellectual property
- The protection of technical inventions and how to safeguard their commercialisation
- Patents as a source of technical and business information
- Practical aspects of intellectual property in day-to-day research, at the workplace and for the formation of start-ups.

Case studies will illustrate and deepen the topics addressed during the lecture.

The seminar will include practical exercises on how to use and search patent information. Basic knowledge of how to read and evaluate patent documents as well as how to use publicly available patent databases to obtain the required patent information will also be provided.

The lecture addresses students in the fields of engineering, science and other related technical fields.

851-0738-00L
Intelectual Property: Introduction

Abstract
The course provides an introduction to Swiss and European intellectual property law (trademarks, copyright, patent and design rights). The legal principles are developed based on current cases.

Objective
The aim of this course is to enable students at ETH Zurich to recognize which rights may protect their creations, and which rights may be infringed as a result of their activities. Students should learn to assess the risks and opportunities of intellectual property rights in the development and marketing of new products. To put them in this position, they need to know the prerequisites and scope of protection afforded by the various intellectual property rights as well as the practical difficulties involved in the enforcement of intellectual property rights. This knowledge is imparted based on current rulings and cases.

Another goal is to enable the students to participate in the current debate over the goals and desirability of protecting intellectual creations, particularly in the areas of copyright (keywords: fair use, Creative Commons, Copyleft) and patent law (software patents, patent trolls, patent thickets).

Handouts, prerecorded videos, slides, and other materials
### 851-0735-10L Law for Entrepreneurs

**W 2 credits 2V P. Peyrot**

**Number of participants limited to 100**

**Abstract**

The students shall obtain a basic knowledge about the legal environment of entrepreneurs. They shall be able to recognize and evaluate legal issues connected to an entrepreneurial activity and suggest possible solutions.

**Objective**

- They shall obtain a working knowledge on the legal aspects involved in setting up and managing an enterprise.
- They shall be acquainted with corporate functions as contracting, negotiation, claims management and dispute resolution.
- They shall be familiar with the issues of corporate compliance, i.e. the system to ascertain that all legal and ethical rules are observed.
- They shall be able to contribute to the legal management of the company and to discuss legal issues.
- They shall have an understanding of the law as a part of the corporate strategy and as a valuable resource of the company.

**Lecture notes**

A comprehensive script will be made available online on the moodle platform.

### 851-0703-00L Introduction to Law

**W 2 credits 2V O. Streiff Gnöpff**

**Students who have attended or will attend the lecture "Introduction to Law for Civil Engineering and Architecture" (851-0703-03L) or "Introduction to Law" (851-0708-00L), cannot register for this course unit.**

**Abstract**

This class introduces students into basic features of the legal system. Fundamental issues of constitutional law, administrative law, privatelaw and the law of the EU are covered.

**Objective**

Students are able to identify basic structures of the legal system. They understand selected topics of public and private law and are able to apply the fundamentals in more advanced law classes.

**Content**

- Private law: Contract law (particularly contract for work and services), tort law, property law.
- Public law: Human rights, administrative law, procurement law, procedural law.
- Insights into the law of the EU and into criminal law.

**Lecture notes**

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

**Literature**

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).

### 853-0047-01L World Politics Since 1945: The History of International Relations (Without Exercises)

**W 3 credits 2V A. Wenger**

**Abstract**

This lecture series provides students with an overview of the development of international relations since the end of World War II. The first part of the series deals with the development of and changes in Cold War security policy structures. The second part deals with the period after the transformation of 1989/91; the focus here is on current issues in international security policy.

**Objective**

By the end of the semester, participants should have a solid knowledge of the history and theoretical foundations of International Relations since the end of the Second World War.

**Content**

- Theleure is being supported by a website on Moodle. If you have any questions, please contact Oliver roos (oliver.roos@siopo.geiss.ethz.ch).

**Prerequisites / notice**

- The lecture has been suspended.

**Fostered competencies**

- Concepts and Theories
- Analytical Competencies
- Media and Digital Technologies
- Problem-solving
- Communication
- Negotiation
- Adaptability and Flexibility
- Critical Thinking
- Integrity and Work Ethics
- Self-awareness and Self-reflection
- Self-direction and Self-management

**Literature**

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Further documents will be available online.

### 853-0725-00L History Part One: Europe (The Cradle of Modernity, Britain, 1789-1914)

**W 3 credits 2V H. Fischer-Tine**

**Abstract**

A range of fundamental processes have transformed European societies in the course of the 19th and the 20th centuries. This lecture series asks whether one single model of modernization prevailed on the 'Old Continent' or whether we need to differentiate regionally. A special focus lies on the Swiss experience.

**Objective**

At the end of this lecture course, students can: (a) highlight the most important changes in the "long nineteenth century" in Europe (b) explain their long-term effects; and (c) relate these changes to global developments today.

**Content**

The thematic foci include: Industrialization on the British Isles, urban growth in Switzerland, the difficult road to democracy in Germany, and French individualism.

**Lecture notes**

- Power Point Slides and references will be made available in digital form during the course of the semester.

**Prerequisites / notice**

- Mandatory and further reading will be listed on the course plan that is made available as from the first session.

This lecture series does not build upon specific previous knowledge by the students.

### 701-0703-00L Environmental Ethics

**W 2 credits 2V A. Deplazes Zemp**

**Abstract**

Environmental ethics is a subfield of moral philosophy that explores the ethical implications of human activity on the natural environment. This course will introduce students to the main ethical theories and debates in the field, and to their application to specific environmental issues.

**Objective**

The students shall obtain the following competencies:

1. **Analytical Competencies**
   - They shall have an understanding of the ethical implications of human activity on the natural environment.
   - They shall be able to analyze and evaluate environmental policies and practices.

2. **Concepts and Theories**
   - They shall understand the main ethical theories and debates in the field.
   - They shall be able to apply these theories to specific environmental issues.

3. **Personal Competencies**
   - They shall have developed critical thinking skills.
   - They shall be able to communicate effectively about environmental ethics.

4. **Social Competencies**
   - They shall have improved their ability to work collaboratively in groups.
   - They shall be able to explain and defend their positions on environmental ethics.

5. **Method-specific Competencies**
   - They shall have developed skills in research and writing.
   - They shall be able to present their arguments clearly and persuasively.

6. **Fostered competencies**
   - They shall have improved their ability to think critically and creatively.
   - They shall be able to apply their knowledge to real-world situations.

7. **Self-direction and Self-management**
   - They shall have developed self-directed learning skills.
   - They shall be able to manage their own learning effectively.

**Literature**

Jaap Hage, Bram Akkermans (Eds.), Introduction to Law, Cham 2017 (Online Resource ETH Library)

Further documents will be available online (see https://moodle-app2.let.ethz.ch/course/view.php?id=17512).
The pressing environmental challenges of today demand a critical reflection. Ethics is an important tool for doing so. This lecture introduces the basics of ethics and provides in-depth knowledge of environmental ethics and its debates. This theoretical background will be applied and critically reflected using examples of current environmental challenges.

Objective
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general and specifically regarding the environment. You know basic concepts, positions and lines of argumentation from the debate in environmental ethics, which you have applied and discussed in smaller exercises.

Content
- Introduction to general and applied ethics.
- Overview and discussion of ethical theories relevant to address environmental challenges.
- Familiarisation with various basic standpoints within environmental ethics.
- Cross-section topics, such as sustainability, intergenerational justice, protection of species, etc.
- Practicing of newly acquired knowledge in smaller exercises.

Literature
- Angelika Krebs (Hg.) Naturethik. Grundtexte der gegenwärtigen tier- und ökoethischen Diskussion 1997
- Andrew Light/Holmes Rolston III, Environmental Ethics. An Anthology, 2003
- John O'Neill et al., Environmental Values, 2008
- Konrad Ott/Jan Dierks/Lieske Voget-Klieschin, Handbuch Umweltethik, 2016

Generel introductions:
- Marcus Düwell et. al. (Hr.), Handbuch Ethik, 2. Auflage, Stuttgart (Metzler Verlag), 2006
- Johann S. Acht et. al. (Hr.), Grundkurs Ethik 1. Grundlagen, Paderborn (mentis) 2008

Prerequisites / notice
We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

853-0061-00L Introduction to Cybersecurity Politics W 3 credits 2G M. Dunn Cavelty, F. J. Egloff

Abstract
The lecture is an introduction to global cybersecurity politics. The focus is on the strategic use of cyberspace by state and non-state actors (threats) and different answers to these new challenges (countermeasures).

Objective
Participants learn to assess the advantages and disadvantages of cyberspace as a domain for strategic military operations. They understand the technical basics of cyber operations and know how technology and politics are interlinked in this area. They understand the security challenges and the rules of states to be active in cyberspace offensively and defensively and are familiar with the consequences for international politics.

Content
We start with an overview of cybersecurity issue from 1980 to today and look at events and actors responsible for turning cybersecurity matters into a security political issue with top priority. After familiarizing ourselves with the technical basics, we look at different forms of cyberviolence and trends in cyber conflicts (technique in social and political practice). Then, we turn to countermeasures: we compare national cybersecurity strategies, examine international norms building, and scrutinize concepts such as cyber-power and cyber-deterrence (technique in social and political regulatory contexts).

Lecture notes
A script with background information and comments on the literature will be made available at the beginning of the semester.

Literature
- Extraction of the script, supplemented with additional literature.

Prerequisites / notice
The procedure for accumulating CP will be explained at the start of term.

853-8002-00L The Role of Technology in National and International Security Policy W 3 credits 2G O. Thränert, A. Dossi, S.-C. Fischer, M. Leese, N. Masuhr

Abstract
The lecture provides an introduction to the role of security and military technologies in the formulation and implementation of national and international security policies. The focus is on challenges posed by new and developing technologies, the transformation of military capabilities, and the question of regulation.

Objective
Participants will gain an in-depth overview of the many ways in which technology is becoming part of security policies and practices, in both civilian and military contexts.

Content

Literature
- Extracted from the lecture notes, supplemented with additional literature.

Prerequisites / notice
The lecture is being supported by a website on Moodle. If you have any questions, please contact Oliver Roos, oliver.roos@sipo.gess.ethz.ch.

851-0650-00L AI4Good ▶ W 3 credits 2G J. D. Wegener

Abstract
The AI4Good is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Data: 01.11.2022 12:41 Autumn Semester 2022 Page 2400 of 2416
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed model in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python) are expected to implement themselves models of various social processes and systems, including agent-based models, complex networks models, decision making, group dynamics, human crowds, or game-theoretical models. Part of this course will consist of supervised programming exercises. Credit points are finally earned for the implementation of a mathematical or empirical model from the complexity science literature and the documentation in a seminar thesis.

Lectures
The lecture slides will be presented on the course web page after each lecture.

Data: 01.11.2022 12:41
Autumn Semester 2022
Page 2401 of 2416
Literature
- Agent-Based Modeling https://link.springer.com/chapter/10.1007/978-3-642-24004-1_2
- Pedestrian, Crowd, and Evacuation Dynamics https://www.research-collection.ethz.ch/handle/20.500.11850/45424
- The hidden geometry of complex, network-driven contagion phenomena (relevant for modeling pandemic spread) https://science.sciencemag.org/content/342/6164/1337

Further literature will be recommended in the lectures.

Prerequisites / notice
- The number of participants is limited to the size of the available computer teaching room. The source code related to the seminar thesis should be well enough documented.
- Good programming skills and a good understanding of probability & statistics and calculus are expected.
- Students need to present a new subject, for which they have not earned any credit points before.
- Good scientific practices, in particular citation and quotation rules, must be properly complied with.

Fostered competencies
- Chatham House rules apply to this course. Materials may not be shared without previous written permission.
- Subject-specific Competencies
  - Concepts and Theories assessed
  - Techniques and Technologies assessed
- Method-specific Competencies
  - Analytical Competencies assessed
  - Decision-making assessed
  - Media and Digital Technologies not assessed
  - Problem-solving assessed
  - Project Management assessed
- Social Competencies
  - Communication assessed
  - Cooperation and Teamwork assessed
  - Customer Orientation not assessed
  - Leadership and Responsibility assessed
  - Self-presentation and Social Influence assessed
  - Sensitivity to Diversity assessed
  - Negotiation not assessed
- Personal Competencies
  - Adaptability and Flexibility assessed
  - Creative Thinking assessed
  - Critical Thinking assessed
  - Integrity and Work Ethics assessed
  - Self-awareness and Self-reflection assessed
  - Self-direction and Self-management assessed

Abstract
The AI4Good course is a hackathon turned into a full course. At the beginning, stakeholders active in the development sector will describe several problems that could be solved with a machine learning approach. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Progress will be discussed with all course members.

Objective
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

Content
The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning. Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students’ initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Prerequisites / notice
- Students with a strong background in machine learning and excellent programming skills (preferably in Python)
The course is focused on the investigation of scientific thought between 1000 and 1700, that is to say the period that saw the flourishing of natural philosophy and the birth of the modern scientific method. Several case-studies, taken from different scientific fields (especially algebra, astronomy, and physics) are presented in class in order to examine the relation between science and philosophy and the shift from medieval times to the early modern world.

851-0742-01L Contract Design II
- **Type**: W
- **ECTS Credits**: 1
- **Lecturer**: A. Stremitzer

**Objective**: To become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

**Abstract**: The course is taught by Professor Alexander Stremitzer (https://lawecon.ethz.ch/group/professors/stremitzer.html).

**Prerequisites / notice**: To be considered for Contract Design II, you must have completed Contract Design I in the same semester. Students can only register for Contract Design II after having obtained approval by Prof. Stremitzer.

**Contract Design II** is a masterclass in the form of an interactive clinic that allows you to deepen your understanding of contracting by applying insights from Contract Design I to a comprehensive case study. Together with your classmates, you are going to advise a (hypothetical) client organization planning to enter a complex transaction on how to structure the underlying contract.

**Participatory Resilience**

851-0426-00L

**Objective**: To enable you to work under the close supervision of your professor and his team, only a small group of students with backgrounds in law, business, or engineering, is admitted to this course. This simulation is time-consuming and challenging. Hence, we can only admit the most successful and motivated students to this class. Further information on the application process will follow.

851-0601-00L Participatory Resilience
- **Type**: W
- **ECTS Credits**: 3
- **Lecturer**: D. Helbing, J. Argota Sánchez-Vaquero, C. I. Hausladen, S. Mahajan

**Abstract**: The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience.

**Objective**: The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

**Content**: The Participatory Resilience hackathon is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

**Prerequisites / notice**: It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.

**Autumn Semester 2022**

**International Environmental Politics**

860-0023-00L

- **Type**: W
- **ECTS Credits**: 3
- **Lecturer**: T. Bernauer

**Abstract**: This course focuses on the conditions under which problem solving efforts in international environmental politics emerge and evolve, and the conditions under which such efforts and the respective public policies are effective.

**Objective**: The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they are or could be solved.

**Content**: This course deals with how and why international problem solving efforts (cooperation) in environmental politics emerge and evolve, and under what circumstances such efforts and the respective public policies are effective. Based on concepts and theories of political economy, political science, and public policy, various examples of international environmental politics are discussed, for example the management of international water resources, political responses to global warming, the protection of the stratospheric ozone layer, the reduction of long-range transboundary air pollution, protection of biodiversity, how to deal with plastic waste, and the prevention of pollution of the oceans.

The course is open to all ETH students and visiting students from other universities. Participation does not require previous coursework in the social sciences.

After passing an end-of-semester test (requirement: grade 4.0 or higher) students will receive 3 ECTS credit points. The workload is around 90 hours (meetings, reading assignments, preparation of test).

Visiting students (e.g., from the University of Zurich, exchange students) are subject to the same conditions. Registration of visiting students in the web-based system of ETH is compulsory.

This course will take place on campus (ETH Main Building, HF F.3). There will be no live-streaming, and the course is NOT in hybrid (on-campus plus online) format. However, the lecture will be recorded and the recordings will be made available via the Moodle platform for this course 1-2 days after the respective lecture for students who are unable to attend in person.
On completion of this lecture, you have acquired the ability to identify, analyze, critically reflect and resolve ethical challenges in general assessed.

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, the processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on System of swiss planning law, assessed. O. Bucher

Critical Thinking 2G

Environmental Policy of Switzerland 2V

Environmental Ethics 2 credits

Environmental Policy 2 credits

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples.

The processes of change, overuse or destruction of the natural environment through humans have historically placed high demands on social and political institutions. In the interplay between the environment, society and economy, the environmental policy field encompasses the sum of public measures that have the goal to eliminate, reduce or avoid environmental degradation. The course systematically presents the basics of environmental policy instruments, actors, programs and processes as well as their change over time. Invited practitioners will provide us with insight regarding the current developments in forest, water and spatial planning policies. A key aspect is the distinction between politics and political science and specifically environmental policy.

The detailed semester program (syllabus) is made available to the students at the beginning of the semester. During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.

We expect participants to engage in and contribute to discussions for keeping the course interesting and lively.

Environmental Policy 3 credits

Environmental Ethics 3 credits

This course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples. The detailed semester program (syllabus) is made available to the students at the beginning of the semester. During the lecture we will work with Moodle and eduApp. We ask that all students register themselves on these platforms before the lecture and to bring a laptop, tablet or smartphone to class, so that you can complete exercises using Moodle and eduApp.

The course presents the basics of public policy analysis and the specific characteristics of Swiss environmental policy. Policy instruments, actors and processes are addressed from a political science perspective both theoretically as well as by means of current Swiss environmental policy examples.
Given a specific problem in global development, students shall learn to self-responsibly design, implement and experimentally evaluate a suitable solution. Students will also learn to critically evaluate their ideas and solutions together with all course members in a broader context that go beyond mere technical solutions, but touch on ethics, local culture etc., too.

The AI4Good course is a hackathon turned into a full course. At the beginning of the course, stakeholders (e.g., NGOs) active in the development sector will describe several problems that could be solved with a machine learning approach. Organizers of the course will make sure that only those problems are selected that are suitable for a machine learning approach and where sufficient amounts of data (and labels) are available. Students will organize themselves into small groups of 3-5 students, where each group works on solving a specific problem. Students will spend the semester on designing, implementing, and testing suitable solutions using machine learning.

Every two weeks, each group will present ideas and progress during a short presentation followed by a discussion with all course members. At the end of the course, students will present their final results and submit source code. In addition, they will describe the developed method in form of a scientific paper of 8 pages. Grading will depend on the source code, the paper, and active participation in class.

Note: The course AI4Good is not related to Hack4Good, which is a students’ initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

851-0724-01L Real Estate Property Law

Objective
Particularly suitable for students of D-ARCH, D-BAUG, D-USYS

Content
1. The legal principles of real estate property law can be correctly interpreted and applied in daily life.
2. Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss).

Abstract
2. Real estate property law (esp. content, acquisition, restrictions under private and public law, transmission and loss).

Objective
Participatory Resilience

Abstract
The legal principles of real estate property law can be correctly interpreted and applied in daily life.

Lecture notes
Abgegebene Unterlagen: Skript in digitaler Form

Literature
- M. Hagner, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

Prerequisites / notice
Students with a strong background in machine learning and excellent programming skills (preferably in Python)

851-0157-28L Life and Death

Objective
Particularly suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS

Content
This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Abstract
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Prerequisites
Learn more about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Method-specific Competencies

Person-specific Competencies

- Adaptability and Flexibility
- Self-awareness and Self-reflection
- Self-direction and Self-management

- Leadership and Responsibility
- Co-operation and Teamwork
- Customer Orientation
- Project Management

- Sensitive to Diversity
- Communication
- Negotiation
- Media and Digital Technologies
- Problem-solving
- Analytical Competencies
- Decision-making

- Critical Thinking
- Integrity and Work Ethics
- Sensitivity to Diversity

- Creativity
- Critical Thinking

- Social Competencies

- Project Management not assessed
- Leadership and Responsibility not assessed
- Co-operation and Teamwork not assessed
- Sensitivity to Diversity not assessed
- Negotiation assessed

- Media and Digital Technologies assessed
- Decision-making assessed
- Project Management not assessed

851-0426-00L Paul Feyerabend's Anarchistic Theory of Knowledge

Objective

Content
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Abstract
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

851-0601-00L Participatory Resilience

Objective

Content
We will start this seminar with a close reading of Paul Feyerabend's Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

Note: The course AI4Good is not related to Hack4Good, which is a students’ initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

851-0157-28L Life and Death

Objective
Particularly suitable for students of D-BIOL, D-HEST, D-CHAB, D-USYS

Content
This course explores the relation between the scientific investigation of life and cultural notions of death from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Abstract
There is only one certainty in life: death. This brute fact has animated much thought and work in theology, art and philosophy - but also in the natural sciences, such as biology and medicine. Questions regarding health and disease, evolution, extinction and immortality have played a crucial role in this connection. This course aims to explore above relations - the relations between the scientific investigation of life and cultural notions of death - from a historical perspective (assuming there is no such thing as the scientific investigation of death). While the course covers the times from antiquity up to the present, the main emphasis will be placed on the modern life sciences since the 19th century.

Prerequisites
Learn more about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.

Method-specific Competencies

Person-specific Competencies

- Adaptability and Flexibility
- Self-awareness and Self-reflection
- Self-direction and Self-management

- Leadership and Responsibility
- Co-operation and Teamwork
- Customer Orientation
- Project Management not assessed

- Sensitive to Diversity
- Communication
- Negotiation assessed
- Media and Digital Technologies assessed
- Decision-making assessed
- Project Management not assessed

851-0426-00L Paul Feyerabend's Anarchistic Theory of Knowledge

Objective

Content
Paul K. Feyerabend characterized his magnum opus “Against method” as an “anarchistic theory of knowledge”. In this book, he crusaded against analytical philosophy of science and critical rationalism. Feyerabend’s advocating for a variety of forms of knowledge has been debated heatedly, but is still relevant for contextualizing the role of science in society.

Abstract
It is the aim of this seminar to become acquainted with the epistemology of Paul Feyerabend and to analyse its relevance for our time.

851-0601-00L Participatory Resilience

Objective

Content
We will start this seminar with a close reading of Paul Feyerabend's Wider den Methodenzwang (https://www.suhrkamp.de/buch/paul-feyerabend-wider-den-methodenzwang-t-9783518281970) (acquisition and reading of this book are required) and continue with the analysis of selected chapters from Feyerabend’s other monographs in order to unveil the connections between epistemology, science, freedom and Enlightenment for the present age.

- Meinrad Huser, Darstellung von Grenzen zur Sicherung dinglicher Rechte, in ZBGR 2013, 238 ff.

Note: The course AI4Good is not related to Hack4Good, which is a students’ initiative organized by the Analytics Club at ETH. For more information about Hack4Good check out the website: https://analytics-club.org/wordpress/hack4good/.
The course is organized around the communicative tasks that participants learn to perform. These relate to the university environment and

French B2-C1: Language and Literature

The Participatory Resilience hackathon aims to discuss and create potential solutions to address problems related to urban resilience using open-source digital tools and participatory methods. It will allow participants from different backgrounds and expertise to exchange ideas, discuss best practices, and build innovative open-source solutions that promote participation and resilience. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

The course provides opportunities to understand what role participatory approaches can play in making cities more resilient. A particular focus will be on understanding how open data, code, knowledge, and service platforms can increase digitally assisted cooperation and promote participatory resilience.

The Participatory Resilience course is a hackathon. At the beginning of the course, the lecturers will explain the concept of participatory resilience and discuss the importance of participatory, interactive, and cooperative approaches for managing complex systems. Participants will focus on the resilience of urban systems, as these are the ones that are particularly prone to many kinds of environmental and social disruptions. They will discuss several problems that could be solved using open-source hardware/software, the Internet of Things (IoT), and Machine Learning. Lecturers and other course facilitators will ensure that only those problems are selected that are suitable for the hackathon's central theme. The students will organize themselves into teams of 3–5 students, where each group works on solving a specific problem. At the end of the course, the teams will demonstrate their hackathon prototype and give a short presentation to an interdisciplinary jury on the last day.

We encourage students from different backgrounds and expertise to participate in this course.

Please visit our website: https://participatoryresilience.ch/

It is advisable to have some experience with hardware/software development, prototyping (for example, with Raspberry Pi), and data analysis.

Language Courses of the UZH and ETH Zurich

A maximum of 3 credit points from language courses may be recognised in the category "Science in Context" throughout the entire bachelor's and master's degree program. Moreover, the following restrictions apply: In the case of the European languages English, French, Italian and Spanish, only advanced language courses from level B2 will be credited. German language courses are credited from level C2.

Only the courses listed below will be recognized as "Science in Perspective" courses.

Course fees: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html
Registration dates: https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursegebuehren1.html

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<tr>
<td>Abstract</td>
<td>This course offers participants the opportunity to read short stories in order to raise their awareness of linguistic aspects and cultural issues in the Francophone world, and to improve their oral skills, mainly through oral presentations.</td>
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<tr>
<td>Objective</td>
<td>The primary objective of this course is to develop participants' written comprehension and, more specifically, to refine their perception of the implicit meanings and cultural aspects present in the literary texts proposed for reading. The course further aims to raise participants' awareness of contemporary cultural issues in the Francophone world. Another goal is to improve participants' oral skills, specifically so they can deliver structured presentations and express personal, informed, and nuanced opinions.</td>
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<td>This course offers participants the opportunity to initiate and practice debating in French by developing and improving specific linguistic tools in order to allow them to speak fluently in controversial discussions.</td>
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<td>Objective</td>
<td>The objective of this course is to familiarize participants with the performance of communicative tasks specific to the academic world and, in so doing, to consolidate their general production and comprehension skills (oral and written) at B2 level.</td>
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<td>Abstract</td>
<td>This course offers participants the opportunity to initiate and practice debating in French by developing and improving specific linguistic tools in order to allow them to speak fluently in controversial discussions. More specifically, it aims at participants' production of clear and reasoned statements to ensure better communication. An additional goal is to improve participants' listening comprehension skills.</td>
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<tr>
<td>Objective</td>
<td>This course allows participants to develop their speaking skills through active contributions in debates. More specifically, it aims at participants' production of clear and reasoned statements to ensure better communication. An additional goal is to improve participants' listening comprehension skills.</td>
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</table>
corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Based on the main controversial issues of the moment, this course offers participants the opportunity to reflect on the rhetorical tools essential to the art of debate and to put these tools into practice in order to improve their ability to express themselves quickly, effectively, and fluently.

Objective
This course allows participants to develop specific skills in oral expression, as well as comprehension, in the context of controversial discussion. After observing various practices and rhetorical tools in the art of debate in an initial phase, participants put the theory into practice in order to produce clearly structured argumentation and improve their ability to interact effectively rhetorically and quickly in a controversial debate.

851-0816-05L French B2-C1: Textual Grammar

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
This course offers participants the opportunity to recognize, practice, and improve some of the fundamental and relevant linguistic tools they need in order to write academic texts in French.

Objective
The main objective of this course is to improve participants’ competence in written French through the mastery of grammatical rules and their practical application; this will ensure the correctness of participants’ utterances at text level and help them with some difficult areas of the French language. The course focuses on a descriptive approach of linguistic tools to improve written academic French (reports, abstracts) and business writing in general (covering letters) through targeted exercises.

851-0826-06L Italian B2-C1: Outside the Classroom

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
This course allows participants to practice Italian in a real-life situation: At the Zurich art museum (Kunsthaus), participants look at art works while listening to an Italian audio guide; they then discuss the art. The course alternates between seven museum visits and seven in-class lessons. At home, participants study their chosen art works in more depth and prepare oral and written summaries.

Objective
The course uses art as a means for participants to practice all four language skills: Reading, writing, speaking, and listening. Further activities enable participants to enhance vocabulary and grammar learning. Participants receive written feedback on their written work, and recurring errors are discussed in class.

851-0826-03L Italian B2-C1: Language Structure

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
The course gives participants the opportunity to broaden and intensify their knowledge of complex morphosyntactic structures. The objective is to improve their proficiency in expressing complex content.

Objective
The course helps participants to explore various ways in which they can express complex thoughts and ideas through different types of subordinate clauses, including consecutive, concessive, and hypothetical sentences, and indirect speech. Using a range of written and oral activities, participants also practice aspects of grammar that often pose difficulties at an advanced level: verb tenses and modes, use of articles and pronouns, adjectives and past participle agreement, choice of prepositions, and word order. At the same time, the course focuses on vocabulary expansion.

851-0823-00L English Language and Literature (C1-C2)

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:
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<td>851-0832-10L</td>
<td>Advanced English for Academic Purposes (C1-C2)</td>
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<td>The course aims to:</td>
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<td>No enrolment to this course at ETH Zurich. Book</td>
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<td></td>
<td>* Introduce participants to a variety of literary texts in English</td>
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<td></td>
<td>the corresponding course directly at &quot;Language</td>
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<td>* Help participants to develop critical, creative, and personal approaches to analyzing literary texts and by extension become more astute readers in general</td>
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<td>Center of UZH and ETH Zürich&quot;.</td>
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<td>* Provide participants with an opportunity to enhance and practice their argumentation skills in discussions and in writing</td>
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<td>* Improve the ways in which participants organize their ideas and arguments in a sustained, coherent, and logical manner</td>
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<td>* Impart a life-long interest in literature written in English</td>
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<tr>
<td>851-0846-01L</td>
<td>Spanish B2: Starter</td>
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<td>W</td>
<td>This course is designed for Bachelor's and Master's students from all disciplines who wish to improve their English from C1 towards C2 level.</td>
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<td>No enrolment to this course at ETH Zurich. Book</td>
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<td>Participants should already have reached C1 level (advanced) as defined in the Common European Framework of Reference for Languages (CEFR).</td>
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<td></td>
<td>the corresponding course directly at &quot;Language</td>
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<td>The course is open to participants whose level is above C1.</td>
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<td>Center of UZH and ETH Zürich&quot;.</td>
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<td>The course aims to train and develop linguistic skills at mastery level, with a focus on formal and informal academic lexis, on listening and oral communication skills, and on increasing fluency, accuracy, and complexity of spoken language. Students will work on writing well-structured descriptive texts and argumentative essays, with the aim of fulfilling the language requirements for study at an English-speaking university or following university Master's courses held in English.</td>
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<tr>
<td>851-0846-03L</td>
<td>Spanish B2: Grammar and Communication</td>
<td>2</td>
<td>W</td>
<td>The most important grammar topics of this course are past tense forms, subordinate clauses, linking devices, reported speech, periphrastic verb constructions, and verbs that express change. The course also deals with topics that typically cause problems for higher level learners, including ser/estar, por/para, and indicative and subjunctive forms of verbs.</td>
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<td>No enrolment to this course at ETH Zurich. Book</td>
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<td>In this course, participants improve their comprehension of written and oral texts that deal with current issues, as well as of scientific texts from participants' own fields of study. They are able to analyse various points of view and can create clear and detailed oral and written texts on scientific issues from their field of study, while taking a position and expressing definite views on these issues.</td>
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<td>the corresponding course directly at &quot;Language</td>
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<td>Participants are able to write clear and detailed texts on scientific issues from their specific fields of study.</td>
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<tr>
<td>851-0849-00L</td>
<td>Brazilian Portuguese A1</td>
<td>2</td>
<td>W</td>
<td>This course is designed for participants with no previous knowledge of Portuguese.</td>
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<td>No enrolment to this course at ETH Zurich. Book</td>
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<td>In the course, participants learn simple basic vocabulary, common daily idiomatic expressions, and fundamental grammar. The focus is on the phonetic features of Portuguese language. Intercultural and cultural issues relating to Brazil are also taken into consideration.</td>
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<td>the corresponding course directly at &quot;Language</td>
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<td>Participants can understand and form simple questions, messages, and requests.</td>
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</table>
corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
This course is designed for participants with a basic knowledge of Portuguese (level A1). The course deals with everyday topics. Participants practice simple forms of communication as these occur in daily life. Lexical and linguistic structures are taught within these contexts. Intercultural and socio-cultural issues relating to Brazil are also taken into consideration.

Objective
Participants can talk and write about themselves and everyday topics using simple sentences. They can take part in simple daily conversations, understand and write simple messages, describe an event in a time sequence, and express wishes, assumptions, and recommendations.

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Data: 01.11.2022 12:41
Autumn Semester 2022
Page 2409 of 2416
## Russian I (A1.1)

The course is the first part of a five-semester Russian course. The goal of the course is for participants to build up a basic vocabulary, learn the basics of Russian grammar, and are introduced to Russian culture.

**Objective**

Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A1.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence.

### 851-0855-00L Russian III (A2.1)

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

**Course fees:**


**Registration dates:**


**Objective**

Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A2.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Talking about your relatives and family; talking about past and future events; expressing your views on things you (don’t) like; expressing your opinion; and requesting information (including about directions and the weather).

**Abstract**

Russian III leads to A2.1 level on the Common European Framework of Reference for Languages. The course is the third part of a five-semester Russian course. In this course, participants extend their ability to express themselves, in particular regarding daily life (eating, shopping) and work and education (daily routines); it also extends participants’ grammar skills.

### 851-0853-00L Russian V (A2.2+)

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

**Course fees:**


**Registration dates:**


**Objective**

Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening skills at A2.2+ level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and speaking about yourself (including about your personal and professional identity and your interests); and asking for information and requesting services.

## Swedish I (A1.2)

Swedish I leads to A1.2 level on the Common European Framework of Reference for Languages. The course is the first part of a two-semester Swedish course. The focus is on speaking, listening comprehension, and reading comprehension skills at A1.2 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life.

### 851-0889-02L Swedish II (A2.1)

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

**Course fees:**


**Registration dates:**


**Objective**

Participants are able to use Swedish adequately in selected areas. The focus is on speaking, listening comprehension, and reading comprehension skills at A2.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence.

**Abstract**

Swedish II leads to A2.1 level on the Common European Framework of Reference for Languages. The course is the second part of a two-semester Swedish course. The focus is on speaking, listening comprehension, and reading comprehension skills at A2.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and speaking about yourself (including about your personal and professional identity and your interests); and asking for information and requesting services.

## Swedish (A2.1)

Swedish I leads to A1.2 level on the Common European Framework of Reference for Languages. The course is the first part of a two-semester Swedish course. The focus is on speaking, listening comprehension, and reading comprehension skills at A1.2 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life.

### 851-0851-00L Russian I (A1.1)

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

**Course fees:**


**Registration dates:**


**Objective**

Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A1.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and speaking about yourself (including about your personal and professional identity and your interests); and asking for information and requesting services.

**Abstract**

Russian I is the first part of a five-semester Russian course. The course leads to A1.1 level on the Common European Framework of Reference for Languages. The goal of the course is to introduce participants to the Cyrillic alphabet and to Russian phonetics; participants build up a basic vocabulary, learn the basics of Russian grammar, and are introduced to Russian culture.

**Course fees:**


**Registration dates:**


**Objective**

Participants are able to use Russian adequately in selected areas. The focus is on speaking, reading comprehension, and listening comprehension skills at A1.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and speaking about yourself (including about your personal and professional identity and your interests); and asking for information and requesting services.

## Swedish (A1.2)

Swedish I leads to A1.2 level on the Common European Framework of Reference for Languages. The course is the first part of a two-semester Swedish course. The focus is on speaking, listening comprehension, and reading comprehension skills at A1.2 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life.

### 851-0850-00L Swedish III (A2.1)

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

**Course fees:**


**Registration dates:**


**Objective**

Participants are able to use Swedish adequately in selected areas. The focus is on speaking, listening comprehension, and reading comprehension skills at A2.1 level of the Common European Framework of Reference for Languages, and on developing cultural competence. Special importance is attached to an academic environment and student life. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and speaking about yourself (including about your personal and professional identity and your interests); and asking for information and requesting services.
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Japanese I A1.1

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Japanese I leads to A1.1 level on the Common European Framework of Reference for Languages. It is the first part of a five-semester Japanese course. The goal of the course is for participants to learn the basic vocabulary and sentence structures needed to communicate in everyday situations. This includes an introduction to Hiragana and Katakana syllabic writing and use in word processing.

Objective
Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Special importance is attached to an academic environment and student life. In addition, the two syllabic writing systems and the use of Japanese computer word processing are learnt. Content areas that are embedded in various communicative tasks include: Greetings, introducing yourself, and talking about yourself (personal and professional identity, studies, interests, daily life); asking for information; and requesting services.

Japanese I (A1.1)

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Elementary introduction to the Japanese language. Students acquire a basic vocabulary together with the most frequently used sentence structures, as well as the Hiragana and Katakana syllabaries. Reading and writing training includes use of the computer for Japanese text editing.

Objective
Everyday conversation / Reading simple texts written with Hiragana and Katakana syllabaries / Writing simple texts about everyday topics using the Hiragana and Katakana syllabaries on the computer.

Japanese III A2.1

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Japanese III leads to A2.1/A2.2 level on the Common European Framework of Reference for Languages. It is the third part of a five-semester Japanese course. The goal of the course is for participants to learn the basic vocabulary and sentence structures needed to communicate in everyday situations. This includes an introduction to Hiragana and Katakana syllabic writing and use in word processing.

Objective
Participants are able to use the Japanese language adequately in selected areas. The focus is equally on fostering speaking, listening, writing, and reading skills at A2.1/A2.2 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. Grammar skills are also reviewed and extended. Participants learn about 60 new Kanji, thus improving their reading skills. The following content from daily interactions is dealt with: Dealing with personal problems, giving advice, expressing wishes, and making assumptions.

Japanese V A2.2 - B1.1

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

Abstract
Japanese V leads to A2.2/B1.1 level on the Common European Framework of Reference for Languages. It is the final part of a five-semester Japanese course. The goal of the course is for participants to learn colloquial Japanese, read texts in Sino-Japanese mixed script, extend their basic vocabulary and sentence structures, and practice listening comprehension.

Objective
Participants are able to communicate orally in specific situations and read everyday texts in Sino-Japanese mixed script. The focus is equally on fostering speaking, listening, writing, and reading skills at A2.1/B1.1 level of the Common European Framework of Reference for Languages, as well as on the development of cultural competence. The following content from daily interactions is dealt with: Various daily activities (logical sequences, expressing regrettable and gratifying events), distinguishing between, and using, deferential and informal language.

Latin Reading Course: "Omnia vincit Amor": Love Stories from the Poet Ovid

W 2 credits 2G University lecturers

Latin Reading Course: "Omnia vincit Amor": Love Stories from the Poet Ovid

W 2 credits 2G University lecturers
This course gives participants an initial insight into the contemporary reality of the global Spanish-speaking community through journalistic texts. You will be reading Norwegian literature with ease and discussing various themes both in speech and in writing. The general topic of the course are love stories in Latin poetry. The skills they practice in this approach include reading, writing, and oral interaction, and the course includes reading and writing activities and oral debates.

### Objective
Students gain an understanding of various aspects of a new topic and are able to analyse and contrast these aspects within a wider context. Participants reactivate, review, and improve their language skills (vocabulary, morphology, morphosyntax) by applying these skills to texts and in exercises (translation competence, text analysis).

### Content
On the basis of didactically prepared texts (especially from Ovid) unfamiliar stories will be read and examined. Metrical reading (hexameter) also will be exercised.

### Lecture notes
Die im Kurs verwendeten Unterrichtsmaterialien werden den Teilnehmenden zugestellt bzw. in den Stunden verteilt oder auf einer elektronischen Unterrichtsplattform verfügbar gemacht.

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<td>851-0856-06L</td>
<td>Spanish B2-C1: The Realities of the Hispanic World</td>
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<td>851-0849-03L</td>
<td>Brazilian Portuguese A2-B2: Urban Popular Music</td>
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Abstract
In this course, participants engage with various themes of urban popular music in Brazil. They gain an understanding of some aspects of culture and the history of Brazil in relation to various music genres, periods of artistic expression, main composers, and interpreters of Brazilian music.

Objective
The aim of this course is to expose the participants to the language with a musical approach using linguistic and cultural resources to develop and improve their oral and written learning and communication skills.

851-0846-02L Spanish B2-C1: Language and Cinema
Does not take place this semester. No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

W 2 credits 2G University lecturers

Abstract
The course introduces specific thematics in Spanish-speaking regions or countries through the cinema, taking into account the geopolitical and cultural spectrum of the Spanish language.

Objective
The course aims to visual observation, development of ideas, presentation, and interaction. Some basic elements of movie-making are presented.

The participant gets familiarized with images, customs, dialogs and vocabulary, carrying out an observation, analysis, and comment of these elements. Glossaries of different linguistic regions are created.

851-0856-04L Spanish B2-C1: Grammar and Communication
Does not take place this semester. No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

W 2 credits 2G University lecturers

Abstract
The main subject matter of this course includes a systematic discussion of the usage of past tenses; subordinate clauses; linking expressions; reported speech; periphrastic verb constructions; and verbs of change. In addition, participants undertake individual reading of various text types, with a particular emphasis on technical subjects and/or subjects related to their fields of study

Objective
In this course, participants acquire oral and written academic communication skills; they acquire knowledge of the grammar areas relevant to B2-C1 level of the Common European Framework Reference for Languages; and they consolidate previously acquired grammar.

Does not take place this semester. No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

W 1 credit 1G University lecturers

Abstract
This course offers participants the opportunity to carry out a "case study" based on a topical issue in order to practice and improve the four language skills by developing a fictitious but plausible scenario that requires the use of specific rhetorical, lexical, and pragmatic tools. The main objective of this course is to give participants an opportunity to practice and improve the four language skills (speaking and listening comprehension, writing and reading comprehension) through "case studies." Participants present a complex topic and interact by defending a point of view and/or responding to objections. In addition, the course allows participants to develop their knowledge of Francophone culture (the media and the press).

851-0820-01L French B2-C1: Language and Cinema
Does not take place this semester. No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:

Registration dates:

W 2 credits 1G University lecturers

Abstract
This course offers participants a choice of films that reflect recent issues in order to raise their awareness of the ongoing concerns of contemporary French cinema, and also to enable them to improve their speaking skills, mainly through oral presentations.
The primary objective of this course is to develop participants' listening comprehension skills and more specifically, to improve their understanding of implicit and cultural meanings of the films on the program. It further aims to raise participants' awareness of the history, aesthetics, and contemporary issues of French cinema. The second objective of the course is to improve participants' speaking skills, especially by giving them the opportunity to produce structured presentations and to express their personal, informed, and nuanced opinions.

851-0834-17L Spanish B2: Oral Interaction

Does not take place this semester.

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich":

Course fees:

Registration dates:

Abstract
Participants practice a range of oral interactions, such as casual and formal conversation, interviews, debates, negotiations, and presentations. They discuss current issues and their fields of study and/or work.

Objective
The course aims to expose participants to a range of conversational situations, providing them with tools that help them to improve their ability to perform various tasks linguistically and socially.

851-0826-04L Italian B2-C1: Language and Literature

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich":

Course fees:

Registration dates:

Abstract
The course approaches the Italian language through short stories, relevant both for their linguistic structures and content, which is related to historical and sociocultural realities typical for Italy. Participants discuss the use of lexical and syntactic conventions implemented through means of oral and written presentations, class discussions, reflections, and targeted exercises.

Objective
The course offers participants the opportunity to:
- Better understand complex literary texts
- Be able to grasp nuances of meaning expressed through certain lexical and syntactical choices more effectively
- Learn how to express themselves clearly and in a differentiated way
- Understand through short narrative texts some cultural and social realities typical of Italy

851-0826-05L Italian B2: Italian for Academic Purposes

Does not take place this semester.

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich":

Course fees:

Registration dates:

Abstract
In this course, participants examine and write/prepare various academic text genres, including scientific essays, abstracts, oral presentations, and handouts.

Objective
The course aims to deepen participants' mastery of academic language. By reading scientific texts and listening to university lectures, participants analyze and study the linguistic structures of these text genres and learn specialist vocabulary from their field of study.

851-0879-01L Chinese V 2.2+

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich":

Course fees:

Registration dates:

Abstract
Chinese V requires level A2.2. of the Common European Framework of Reference. The goal of the course is for participants to communicate orally about selected topics from different areas.

Objective
The participants are able to talk about selected topics. The focus is on oral language skills. However, listening, reading and writing skills are also trained. Participants can work with texts or audios/videos using aids such as pop-up dictionaries and writing on the computer.

Content
The vocabulary of 600 words, which was acquired in the courses I-IV, will be enlarged by another 150. Which means, that of the ten lessons of the book, five will have to be mastered.

Lecture notes
This course will be supported by a module in OLAT. The participants will be asked to do some of their portfolios on OLAT.

Literature
HSK Standard Course 4, Teil 1, HSK标准教程4 上 (含1MP3)
ISBN: 9787561939031 und HSK标准教程4 上 练习册 (含1MP3)

Prerequisites / notice
It is mandatory that the course Chinese IV has been successfully completed. Or else, a certificate of the HSK 3 examination in the last two years is provided.
851-0867-00L  Arabic I-III (Fast Track) A1-A2.1

No enrolment to this course at ETH Zurich. Book the corresponding course directly at "Language Center of UZH and ETH Zürich".

Course fees:  https://www.sprachenzentrum.uzh.ch/en/Sprachkurse/Kursgebuehren1.html

Registration dates:  https://www.sprachenzentrum.uzh.ch/en/Sprachkurse.html

Abstract  Arabic I-III (fast track) leads as intensive course to A2.1 level on the Common European Framework of Reference for Language. The target group are people understanding or speaking an Arabic dialect who want to learn Standard Arabic, people who are able to read the Arabic script without speaking Arabic, and people having a lot of experience in learning languages who can invest plenty of time.

Objective  Participants are able to use the Arabic language adequately in selected areas and can conduct themselves in a culturally appropriate manner. To this end, the following content is dealt with: Talking about your life; daily routines; expressing wishes, commands, and eventualities, talking about language and language learning (meta-language skills), writing messages and short texts. In terms of grammar, this course attaches particular importance to the basic principles of the grammar of Standard Arabic and its verbal system. Among the cultural and meta-language skills are the creation of awareness regarding the difference between the Arabic varieties and registers.

Science in Perspective - Key for Type

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<tr>
<th>W+</th>
<th>Eligible for credits and recommended</th>
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<tr>
<td>O</td>
<td>Compulsory</td>
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<tr>
<td>W</td>
<td>Eligible for credits</td>
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<tr>
<td>E-</td>
<td>Recommended, not eligible for credits</td>
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<tr>
<td>Z</td>
<td>Courses outside the curriculum</td>
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<tr>
<td>Dr</td>
<td>Suitable for doctorate</td>
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Key for Hours

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<tr>
<th>V</th>
<th>lecture</th>
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<td>G</td>
<td>lecture with exercise</td>
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<td>U</td>
<td>exercise</td>
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<td>revision course / private study</td>
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ECTS  European Credit Transfer and Accumulation System

Special students and auditors need special permission from the lecturers.